CUTTING BACK THE STEM:

CULTIVATING LIBERAL ARTS IN OFFICER ACCESSIONS

BY

MAJOR STEPHEN L. MEISTER

A THESIS PRESENTED TO THE FACULTY OF

THE SCHOOL OF ADVANCED AIR AND SPACE STUDIES

FOR COMPLETION OF GRADUATION REQUIREMENTS

SCHOOL OF ADVANCED AIR AND SPACE STUDIES

AIR UNIVERSITY

MAXWELL AIR FORCE BASE, ALABAMA

JUNE 2016

APPROVAL

The undersigned certify that this thesis meets master's-level standards of research, argumentation, and expression.

JAMES M. TUCCI (Date)

STEPHEN D. CHIABOTTI (Date)

DISCLAIMER

The conclusions and opinions expressed in this document are those of the author. They do not reflect the official position of the US Government, Department of Defense, the United States Air Force, or Air University.

ABOUT THE AUTHOR

Major Stephen Meister is a 1994 graduate of the University of Nebraska-Lincoln, where he majored in English. He earned his commission through Officer Training School in 2001. Major Meister is a career ICBM officer and a graduate of the TOP HAND professional development program for Air Force missileers. He holds a Master of Arts degree in National Security Studies from American Military University and a Master of Military Operational Art and Science degree from Air Command and Staff College. Major Meister's 14-year career on active duty includes postings in Wyoming, California, and Nebraska, culminating with his last post as Chief, ICBM Strike Planning at United States Strategic Command at Offutt Air Force Base in Omaha.

ACKNOWLEDGMENTS

I would like to acknowledge several people without whose support and help I could not have met this challenge. I want first to thank my classmates from SAASS XXV. Their professionalism and enthusiasm provided the inspiration and encouragement to push through when the going got tough. I am honored and humbled to be part of their company.

I especially want to thank Dr. James Tucci and Dr. Stephen Chiabotti for their willingness to support my non-conventional idea. Their perspectives and insights have been invaluable. They refused to underestimate this old man with an English degree, and for that, I am grateful.

Most importantly, I want to express my sincere appreciation to my family. I did not do a particularly good job of balancing life and school, and they suffered for it. Knowing they were behind me made all the difference in ensuring my success in completing this work. I hope someday I will be deserving of their love, patience, and understanding.

ABSTRACT

The research examines whether the current singular focus on technical education for officer recruiting and accessions risks inhibiting mission success by unnecessarily narrowing the talent pool and stifling critical, creative thinking. The strategic documents guiding the future of the Air Force emphasize the need to move beyond industrial-era constructs. Currently, the USAF singularly emphasizes Science, Technology, Engineering, and Mathematics (STEM) backgrounds in officer recruiting, pre-commissioning education, and accessions. War is not, however, an engineering problem. Tactical and operational effects are vital, but at the strategic level, war is waged in the mind. The future officer corps must use critical, divergent thinking in order to assess a strategic environment, appreciate its complexities, and devise creative approaches. Because the USAF "grows its own" leaders and strategists, it is imperative that new accessions possess habits of mind that foster flexibility and diversity of thought.

The paper begins by assessing whether the current focus on STEM education for officer recruiting and accessions aligns with the Chief of Staff's strategic vision for the future of the force – creative, innovative, critically thinking Airmen ready to face an increasingly complex and uncertain security environment. After describing the Chief's vision, the paper identifies Air Force specialties with particular education requirements to assess whether the focus on STEM degrees is warranted. The author concludes there is a mismatch between current recruiting practice and the Chief's vision. Next, a review of literature on creative, innovative, and critical thinking styles follows with particular attention on how they apply to the profession of arms. The final chapter assesses the relative strengths of STEM and liberal arts education in developing habits of mind that foster creativity, innovation, and critical thinking. The conclusion is that a certain level of familiarity with STEM concepts is advantageous, but an overemphasis on STEM degrees is not only unwarranted, but also harmful, because it indeed inhibits mission success by unnecessarily narrowing the talent pool and stifling critical, creative thinking. The author recommends eliminating the focus on STEM degrees and instead developing assessments for appropriate levels of technical knowledge and critical thinking skills as part of the vetting for officer accessions.

CONTENTS

Illustrations

INTRODUCTION

In June 2002, a new, but not so young, Air Force officer arrived at Francis E. Warren Air Force Base in Cheyenne, Wyoming after being honored as the Distinguished Graduate of Initial Qualification Training for Intercontinental Ballistic Missile (ICBM) operations. This second lieutenant was atypical in several ways. He was 33 years old with no prior enlisted service, but nearly ten years of experience working in the private sector after finishing his degree. Most of his squadron peers had graduated college within the last year and were ten years younger. As he completed local training for certification as a Missile Combat Crew Member he was told a curious thing. If he had waited until that moment to apply for Officer Training School, they would not have accepted him. His age was not the issue. The problem was his Bachelor of Arts degree in English. The Air Force was limiting officer accessions to technical degrees. Fast-forward 13 years and this officer, now a major, is a student at the School for Advanced Air and Space Studies looking for a thesis topic. Such was the genesis of this research project.

The research examines whether the current focus on STEM education for officer recruiting and accessions risks inhibiting mission success by unnecessarily narrowing the talent pool and stifling critical, creative thinking. The strategic documents guiding the future of the Air Force emphasize a purported need to move beyond industrial-era constructs. Currently, the USAF emphasizes Science, Technology, Engineering, and Mathematics (STEM) backgrounds in officer recruiting, pre-commissioning education, and accessions. War is not, however, an engineering problem. Linear convergent thinking is ill suited to the current complex security environment. Tactical and operational effects are vital, but at the strategic level, war is waged in the mind. The future officer corps must use critical, divergent thinking in order to assess a strategic environment, appreciate its complexities, and devise creative

approaches. Because the USAF "grows its own" leaders and strategists, it is imperative that new accessions possess habits of mind that foster critical thinking, adaptive behavior, and diversity of thought.

The paper begins by assessing whether the current focus on STEM education for officer recruiting and accessions aligns with the CSAF's strategic vision for the future of the force – creative, innovative, critically thinking Airmen ready to face an increasingly complex and uncertain security environment. After describing the Chief's vision, the paper identifies Air Force specialties with particular education requirements to assess whether STEM-focused manning issues drive the focus in recruiting. A review of literature on creative, innovative, and critical-thinking styles follows with particular attention on how they apply to the profession of arms. The final chapter assesses education models to identify the relative strengths of STEM and liberal arts education in developing habits of mind that foster creativity, innovation, and critical thinking.

I had intended to examine demographic data to assess any correlation between educational background and mission readiness and career success -- measured by retention rates, promotion rates, and in-residence PME attendance. Unfortunately, publicly accessible demographic-analysis tools capture only the most recent academic discipline. Thus, any advanced degrees would mask undergraduate disciplines which are at the heart of this research. Additionally, policy prevented analysts at the Air Force Personnel Center from assisting me. In lieu, I reviewed 292 biographies of general officers and unearthed some interesting trends. While certainly not quantitatively rigorous, a measure of confidence comes from the fact that data gleaned from the survey of general officer biographies is in line with data on the officer corps as a whole presented in a RAND study on STEM workforce needs.

Several terms at the crux of the research face definitional difficulties. Terms like "creative" and "innovative" have become

ubiquitous in the vernacular, but carry different connotations in different contexts. I deal with these issues directly in the text as appropriate. This is also true for the term “STEM” for which the Air Force has no official definition. It is addressed in the opening chapter. However, the terms non-STEM, liberal arts, and liberal education are used interchangeably throughout the paper to indicate non-technical disciplines. These terms encompass the arts, humanities, social sciences, and business.

Ultimately, the research demonstrates that creativity, innovation, and critical thinking are indeed important capabilities for the profession of arms. Additionally, a multidisciplinary liberal-education approach that includes significant exposure to STEM subjects is best suited to developing these habits of mind. The singular focus on STEM degrees in Air Force officer recruiting and accessions is unwarranted and likely harmful to the long-term interests of the institution. The Air Force should stop overemphasizing STEM degrees and instead determine appropriate levels of STEM-cognizance. Additionally, the institution should develop measurement tools to assess creative and critical thinking as part of the vetting process for officer accessions. These measures would align recruiting efforts with the CSAF’s strategic vision for the future of the force.

Chapter 1

VISION FOR THE FUTURE

Organizations in the 21st Century are confronting sweeping technological, societal, economic, and political changes that are challenging their abilities to serve their constituents and fulfill their missions.

-- Andrew J. Kaslow
Foreword to *Breakthrough Creativity*

The effectiveness of Air Force airpower comes directly from the power of Airmen. While it is natural to define the Air Force in terms of its aircraft, missiles, or satellites, in reality, the Service's unmatched capabilities exist only and precisely because of the imagination, innovation, and dedication of its people.

-- General Mark A. Welsh, III
Global Vigilance, Global Reach, Global Power

Vision for the Future

Beginning in 2013 the Chief of Staff, United States Air Force (CSAF), General Mark A. Welsh III, released a series of forward-looking strategic documents. Building on one another, the documents present the CSAF's vision and plan to carry the Air Force forward for the next 20 to 30 years. One recurring theme that undergirds that vision is the uncertain future wrought by a complex security environment and ongoing fiscal challenges. The spread of advanced technology, global economic and energy pressures, and the evolutionary forces of social change make the twenty-first century a time of unusual volatility. Accordingly, even the best analyses and projections by national security experts cannot predict the time and place of the next crisis with certainty. Moreover, as such crises present themselves (or as we initiate them) they rarely develop as we expect. This is not to say that the nature of warfare will change over the next two decades.

War will remain a clash of wills between thinking adversaries, but it will occur in an environment of increasing uncertainty and rapid change. The character of warfare is becoming far less predictable and more complex. No technology or technique will completely eliminate the fog and friction of warfare. Likewise, adversaries will continue to challenge our military advantage as they seek to achieve their objectives and deny us ours. War will remain an instrument of policy, with associated constraints, restraints, and specified missions for military forces. Navigating the relationship between policy and war, however, will be more challenging in the complex future.[1] The CSAF's strategic documents also chart a course to do just that.

Another recurring theme in the CSAF's vision of the future is the vital importance of innovative, creative, and critically thinking people in answering the challenges of our time. As its title suggests, *The World's Greatest Air Force, Powered by Airmen, Fueled by Innovation: A Vision for the United States Air Force* recognizes Airmen as the power behind the Air Force and stresses the importance of innovation to the Air Force story. This first document in the series rightly identifies "Airmen's ability to rethink the battle" while incorporating new technologies as the fuel for mission accomplishment.[2] Refreshingly, the vision does not conflate innovation with technology itself. Rather, by focusing first on rethinking the battle, the statement acknowledges that advantage in the future relies more on brainpower than firepower. The Chief calls for all Airmen, enlisted, officer, and civilian alike, to find new approaches to the complex challenges ahead.

---

[1] Department of the Air Force, *Air Force Future Operating Concept: A View of the Air Force in 2035*, (Washington, DC: Department of the Air Force, September 2015), 5.
[2] Department of the Air Force, *The World's Greatest Air Force, Powered by Airmen, Fueled by Innovation: A Vision for the United States Air Force* (Washington, DC: Department of the Air Force, 11 January 2013), http://www.osi.af.mil/shared/media/document/AFD-130111-016.pdf.

The July 2014 *America's Air Force: A Call to the Future* lays out a strategic path for the next 30 years. Recognizing that the seeds of that future are being planted today, the document looks ahead to an increasingly dynamic environment and stresses the need to identify and recruit those who possess the character, skills, education, and aptitude to thrive in such a setting. The CSAF stresses that this means not only technical skills, but also critical thinking, adaptive behavior, and diversity of thought. Identifying and capitalizing on those traits will require a more nuanced approach, but if the Air Force is to develop Airmen who can effectively lead the institution into the future, it must start with the right "raw material."[3] This study focuses on pre-commissioning education for that very reason.

Discussion of officer-skill development usually focuses on professional military education (PME). In the Air Force, officer PME begins with Squadron Officer School (SOS), which serves as a centralized leadership-development center for junior officers.[4] Four years of commissioned service is the minimum eligibility requirement, but in practice, most officers attend SOS around the six-year point of their career. The Warfare Studies and Leadership Studies curriculum focuses at the tactical or flight level, rather than operational or strategic levels.[5] This follows from a traditional view that a junior officer's lot in life is to accept his or her role in the existing order. That is to say, he or she is merely an instrument of strategy. According to this way of thinking, company grade officers simply receive and execute orders that someone much higher in the chain of command developed.[6] If this view holds

---

[3] Department of the Air Force, *America's Air Force: A Call to the Future*, (Washington, DC: Department of the Air Force, July 2014) 9.
[4] Air University, *AU Catalog 2015-2016*, (Maxwell AFB, AL: Air University, 2015), 8.
[5] Air University, *AU Catalog 2015-2016*, 144.
[6] Scott A. Silverstone and Renee Ramsey, "Who Are We Teaching – Future Second Lieutenants or Strategic Leaders?: Education for Strategic Thinking and Action," *Infinity Journal Special Edition "International Relations in Professional Military Education*, Winter 2016, 10.

true, perhaps it makes sense to wait four to six years before engaging young officers in formal education in the profession of arms. However, the idea that junior officers cannot be trusted with higher-level decisions no longer makes sense.

Commissioning sources are not merely producing second lieutenants that are proficient in a tactical environment. Recent experiences in Afghanistan and Iraq demonstrate that ground-force lieutenants and captains are indeed strategic actors who must have the intellectual ability to adapt the ways and means of their unit's operations effectively to support higher-level strategic and political goals.[7] Some may argue that this is less the case for Air Force officers largely removed from the close quarters of combat or counter-insurgency operations. Even if one believes this is true, the fact remains that newly commissioned second lieutenants are the future senior strategic leaders of the armed forces, including the Air Force. The military services do not hire senior executives laterally as the business sector does. Simply put, we grow our own. Therefore, pre-commissioning education has strategic significance on two levels. First, it is the foundation for effective action at junior levels of command. Second, it sets the intellectual conditions necessary for continued professional growth as officers advance to senior ranks and strategic-leadership positions.[8]

To meet the global challenges of the twenty-first century, the Air Force looks to position itself as a "profession of choice" in the competition for the country's top talent. As noted in the *Human Capital Annex* to the current *Strategic Master Plan*, finding the best people to become Airmen requires expanding outreach to a more diverse pool of candidates with

[7] Silverstone and Ramsey, "Who Are We Teaching?" 11.
[8] Scott A. Silverstone, "Introduction: Developing Strategic-Minded Junior Officers," *Infinity Journal Special Edition "International Relations in Professional Military Education*, Winter 2016, 6.

unique and valued backgrounds and perspectives.[9] With constrained annual budgets and declining personnel strength, recruiting efforts are increasingly more critical and require more effort to access the individuals we need. Operational imperatives require leveraging diversity and inclusiveness across the force to develop Airmen with the unique skills to match evolving needs and address emerging challenges.[10] The complex strategic environment demands a diverse team of people to overcome obstacles and exploit opportunities. Inclusiveness ensures that we are leveraging the broadest possible set of human resources to produce the maximum number of options. Diverse backgrounds, experiences, and competencies will drive the innovative perspectives that give us agility.[11]

Air Force history is full of examples of the ways that innovative Airmen have brought our core missions together to deliver Global Vigilance, Global Reach, and Global Power. The ingenuity of Airmen was on full display during the first 24 hours of Operation Desert Storm in 1991. The attack plan called for more than 150 attacks against separate targets—more targets in a single day than were attacked by the entire 8th Air Force in the first two years of the combined bomber offensive over Europe during World War II. This degree of complexity and precision was unequaled in the annals of military history. An Airman's new theory of targeting combined with advanced airpower technologies made the operation possible. The introduction of stealth technology and expanded types and numbers of precision weapons were only part of the equation.

A targeting approach based on achieving specific effects rather than widespread destruction created a new concept of operations known as parallel warfare. The simultaneous application of force across the

[9] Department of the Air Force, *Human Capital Annex to the USAF Strategic Master Plan,* (Washington, DC: Department of the Air Force, 21 May 2015), A-6.
[10] Department of the Air Force, *Human Capital Annex,* A-6.
[11] Department of the Air Force, *Strategic Master Plan,* 25-26.

breadth and depth of the theater combined with advanced technology heralded a turning point in the character of warfare that continues to have a defining influence on how we seek to win current and future conflicts.[12] As radical as they were portrayed, these technological aspects were actually evolutionary. The idea, however, was in large measure revolutionary. Media reports, though, gave stealth and precision technology top billing. Thus, they entered the public consciousness as the be-all and end-all of airpower, and by extension, of military power. Unfortunately, this misunderstanding persists in large measure today. Thankfully, though, the institutional Air Force is beginning to see things differently.

The *Air Force Future Operating Concept* portrays skilled Airmen employing advanced technology in innovative ways to deter and defeat adversaries. However, as with the CSAF's other strategic documents, the focus is less on the technology and more on the Airmen. The specific call is for "a balanced pool of Airmen, some with deep expertise and some with diverse experience, supported by a greater and purposeful differentiation of selection, development, and placement to improve proficiency in multi-domain approaches, mission-critical areas, operational design, full-spectrum operations, and cutting-edge technologies."[13] The *Strategic Master Plan* echoes the Chief's vision with a call to reorient the force to the idea that alongside our expertise in conducting cyberspace, ISR, or mobility operations, the ability to cultivate and leverage diverse options is just as much a critical capability that we must integrate into all aspects of how we do business.[14] This integration extends to recruiting:

> An agile Air Force requires agile Airmen. We must adapt our recruiting, development, and retention processes to grow

[12] Department of the Air Force, *Global Vigilance, Global Reach, Global Power for America*, (Washington, DC: Department of the Air Force, August 2013), 10.
[13] Department of the Air Force, *Future Operating Concept*, 43.
[14] Department of the Air Force, *Strategic Master Plan,* 27.

> such Airmen. With mission-critical qualities evolving, we must recruit cutting-edge talent. A complex future demands a new generation of Airmen with a diverse blend of talent suitable for that environment. The Air Force must increasingly develop Airmen with abilities that can exploit the emerging globalized, information-based, and networked environment rather than the industrial processes of the last century. These desired skills influence operations in all domains and across all core missions.[15]

The current approach to officer recruiting and accessions, however, does not match the Chief's vision.

Clouding the Vision

Officer-recruiting and accession efforts prioritize technical education degrees over all others, despite the fact that only five Air Force specialties have mandatory requirements for STEM degrees: The *AFROTC 2015 National Recruiting Strategy* closes with: "AFROTC recruiters must search for and recruit high-quality applicants with a particular focus on diversity and technical degrees."[16] What diversity means is not explicit, but the given rationale includes historic references to desegregation, and people of various backgrounds, cultures, and experiences. Thus, one can infer that racial, ethnic, and gender diversity is the aim.[17] The rationale given for focusing on STEM degrees is more explicit. It is the dogmatic assertion that the Air Force is and must remain a technologically bent military branch due to the nature of its mission. The document states furthermore that STEM degrees fill several "tip-of-the-spear" operational Air Force specialties.[18] Aside from the fact that people, not degrees, fill positions and execute the mission,

---

[15] Department of the Air Force, *Strategic Master Plan,* 13.
[16] Air Force R.O.T.C, *National Recruiting Strategy: The 2015 Vector*, (Maxwell AFB, AL: HQ AFROTC/DOR, June 2015), 11.
[17] Determining whether racial, ethnic, and gender diversity are a useful surrogate for the diversity of thought envisioned by the CSAF is beyond the scope of this study.
[18] Air Force R.O.T.C, *National Recruiting Strategy,* 9.

this statement is problematic because recruiters may interpret it as a tacit requirement for those positions.

The majority of officers in operational career fields do not have, nor do they require, STEM degrees. Assuming the phrase "tip-of-the-spear" carries the commonly accepted connotation of rated operators, it is certainly accurate to say STEM-degreed Airmen fill those positions. However, according to a RAND study on STEM-workforce needs completed in 2014, less than half of rated operators have at least one STEM degree, bachelor's or higher (48 percent of pilots, 35 percent of combat system officers, and 22 percent of air battle managers).[19] In an interview with the RAND researchers, the rated career field manager (CFM) observed that a STEM degree is not necessary for effective performance as a rated officer. The important skills for performance and progression in a rated career field are problem solving, multi-tasking, and stress management, none of which are peculiar to technical fields.[20]

Including non-rated operators in the mix makes the recruiting emphasis on STEM even more suspect. If space and missile operators are included at the pointy end, in May 2010, only 27 percent of 3,600 officers had at least one STEM degree. The space and missile CFM noted that a STEM degree is not essential for these officers since the Air Force provides significant training.[21] In other words, training for Air Force operators does not rely on prior-skills training. Indeed, this author's experience with Officer Space Prerequisite Training and ICBM Initial Qualification Training indicates an assumption by curriculum developers that new accessions are effectively a *tabula rasa*. This makes sense

---

[19] Lisa M. Harrington, Lindsay Daugherty, S. Craig Moore, and Tara L. Terry, *Air Force-Wide Needs for Science, Technology, Engineering, and Mathematics (STEM) Degrees*, (Santa Monica, CA: RAND, 2014), 97.
[20] Harrington, et al., *Air Force-Wide Needs for STEM*, 97.
[21] Harrington, et al., *Air Force-Wide Needs for STEM*, 111-112. The space and missile career fields were still united at the time of the RAND study. With the establishment of Air Force Global Strike Command, the two career fields separated in 2009 in an effort to mitigate years of institutional neglect of the nuclear enterprise. ICBM operators no longer accomplish space operations training.

considering the very specific nature of the career field. Expecting an outside institution to teach specific weapon-system skills such as satellite or ICBM operations would be ludicrous.

The purpose of Air Force training is to ensure that each individual is prepared to meet mission requirements. Air Education and Training Command (AETC) pipeline-training managers ensure that graduates meet those requirements before joining operational units.[22] Since fewer than half of all rated and non-rated operators have STEM degrees, clearly non-STEM-degreed officers are capable of fulfilling mission requirements. Yet, the Air Force Reserve Officer Training Corps (AFROTC) scholarship program for college-bound high school seniors maintains a singular focus on STEM majors as stated on the program's webpage at AFROTC.com:

> The most highly desired majors for AFROTC cadets are electrical engineering, computer engineering, meteorology, nuclear physics and nuclear engineering. Scholarship applicants selecting these majors might receive priority in the scholarship selection process. We encourage HSSP [High School Scholarship Program] applicants to apply and pursue technical and foreign language majors, as they are critical to the Air Force's mission. Technical scholarship offers are awarded at a rate of approximately 80 percent, followed by foreign language majors. Very few foreign language nontechnical scholarships are awarded.
>
> For all nontechnical scholarships, cadets must successfully complete either four semesters of a single foreign language or 24 hours of math and physical science (with a minimum grade of C-) before they graduate/commission.[23]

These very narrow parameters are discordant with the CSAF's vision of an Air Force rich in diversity of thought. If the recruiting focus is to

---

[22] Raymond E. Cooley and Albert A. Robbert, *Air Force Officer Specialty Structure: Reviewing the Fundamentals*, (Santa Monica, CA: RAND, 2009), 11.
[23] Air Force R.O.T.C., "Scholarships: Schools & Majors," https://www.afrotc.com/scholarships/schools.

catch up, it is important to understand how it got this way in the first place.

Two studies from 2010 and 2014 help explain the emphasis on recruiting STEM-degreed officers. Both of them focus on the Air Force's technical-workforce needs and start from the premise that "technical capabilities have always been critical to the missions and roles of the U.S. Air Force in military operations, and these capabilities are rooted in science, technology, engineering, and mathematics (STEM)."[24] This seems reasonable enough. Indeed, it appears to be self-evident. Airpower's genesis was, after all, the technological leap to heavier-than-air flight. The problem is that Airmen often conflate the Air Force's missions and roles with the technical capabilities themselves.

In January 2003, CSAF General John Jumper published the *Chief's Sight Picture* containing his commentary on the identity of the Air Force as captured through air and space core competencies. Prior to this time, Air Force documents listed six core competencies: Air and Space Superiority, Global Attack, Rapid Global Mobility, Precision Engagement, Information Superiority, and Agile Combat Support.[25] General Jumper relegated these to "distinctive capabilities" enabled by the "new" core competencies of *Developing Airmen, Technology-to-Warfighting, and Integrating Operations*.[26] All three seem germane to the study at hand. Unfortunately, General Jumper's description of the first acknowledges Airmen as the lynchpin of combat capability, but does not actually address their development. The discussion of integrating operations is likewise more platitude than substance. The description of the second, however, deserves our attention.

---

[24] National Research Council, *Examination of the U.S. Air Force's Science, Technology, Engineering, and Mathematics (STEM) Workforce Needs in the Future and Its Strategy to Meet Those Needs*," (Washington, DC: National Academies Press, 2010), vii.
[25] Chris J. Krisinger, "Who We Are and What We Do: The Evolution of the Air Force's Core Competencies," *Air and Space Power Journal*, Fall 2003, 17.
[26] John P. Jumper, *Chief's Sight Picture*, 15 January 2003.

General Jumper described the core competency of *Technology-to-Warfighting* thusly:

> Our Air Force has a proud legacy of continually bringing cutting-edge technological capabilities to bear to confront threats to our nation's security. This legacy started a century ago with the dawn of aviation. It continues today, as our wielding of air power pushes the limits of not only the sky, but of outer space and cyberspace. We combine the tremendous technological advancements of stealth, global communications connectivity, global positioning, and more, to put cursors on targets and steel on the enemy. It is our unique ability to apply various technologies in unison so effectively that allows us to translate our air and space power vision into decisive operational capability.[27]

This pervasive focus on technical means further perpetuated a technocratic mindset born of the quick victory in the Gulf War. In a perhaps ironic turn, the limitations of that mindset became clear in 2003 when the quick victory over Saddam Hussein's military in Iraq unraveled, and high-end technological capabilities had less utility in counter-insurgency operations. Nonetheless, General Jumper's *Technology-to-Warfighting* concept formed a central part of the argument for greater emphasis on STEM in one of the aforementioned studies.

The National Research Council (NRC) assessed the Air Force's future STEM-workforce needs at the behest of the Air Force Deputy Chief of Staff for Manpower and Personnel and the Deputy Assistant Secretary of the Air Force for Science, Technology, and Engineering. An ad hoc committee of military, academic, and industry experts held a series of meetings between August 2008 and January 2009. Published in 2010, the NRC report mirrors concerns expressed in the larger society about the declining number of STEM-degreed college graduates. Indeed, the preface makes clear the presumption that this trend is a problem, if not a crisis. Unfortunately, the makeup of the study group appears to have

---

[27] Jumper, *Chief's Sight Picture.*

been members of the same choir chanting to one another. In a chapter on the role of STEM capabilities in achieving the Air Force vision and strategy, the authors acknowledge that strategic documents from 2006 forward no longer include references to a technology-focused core competency.[28] However, rather than acknowledge that the reason the Air Force moved on from this view may have been a realization of the limitations confronted in Iraq, they lament the change and base their argument for STEM's importance on Jumper's vision from 2003. Ironically, their proposed changes for the future remain mired in the past. Nevertheless, despite these limitations, the report does have its merits.

The NRC study acknowledged that operational competence does not necessarily require a STEM degree. In their effort to identify why and where the Air Force needs STEM capabilities in its organic workforce to accomplish its priorities, goals, and objectives, the authors differentiated STEM degrees (i.e., STEM majors) from substantial coursework in STEM disciplines. They determined that in most cases a substantial familiarity with STEM concepts was sufficient. Their preferred term is "STEM-cognizant" to indicate individuals who have acquired a sufficient foundation in the use of the scientific method for decision-making.[29] Though the authors present no real evidence for the assertion of desirability of the scientific method in decision-making, this second tier of STEM competence makes sense for a service so heavily invested in technology.

The study group's rationale for recognizing "STEM-cognizance" comes from the academic model employed at the United States Air Force Academy (USAFA). Graduating and commissioning about a thousand officers a year, approximately 40 percent of whom earn STEM degrees,

[28] National Research Council, *STEM Workforce Needs*, 29-30.
[29] National Research Council, *STEM Workforce Needs*, 17.

USAFA requires all cadets to take a core of STEM courses regardless of major. These 45 hours of coursework form the basis of the Bachelor of Science degree and ensure a level of STEM competence whether the cadet majored in English or management.[30] The NRC committee correctly reasoned that graduates of other accredited institutions that attained a level of STEM competence roughly equivalent to that required by USAFA also have value in meeting Air Force STEM needs whether or not they have a STEM degree. A RAND study a few years later explored similar issues.

As part of a fiscal year 2012 project on STEM, the Air Force Deputy Assistant Secretary for Acquisition Integration, Office of the Assistant Secretary of the Air Force for Acquisition, and the Director, Force Development, Deputy Chief of Staff for Personnel, Headquarters U.S. Air Force commissioned a study by RAND. The research (already referenced above) examined requirements across all Air Force functional areas for STEM-degreed officers. The report suffers from some of the same bias issues as the NRC report described above. First, the research questions centered on STEM academic requirements rather than STEM-related skills. Second, there was an implicit assumption that academic requirements were sound. The primary methodology involved interviewing CFMs and following up with the functional managers above those CFMs to validate the information gathered.[31] This in itself is not problematic. However, in those interviews with CFMs, the researchers reported asking questions that specifically focused on STEM degrees rather than open-ended questions about required skills:

- Which STEM degrees are necessary/important for successful functional performance today and in the future for officer and civilian members doing [*insert career field here*]-related work?

---

[30] National Research Council, *STEM Workforce Needs*, 17.
[31] Harrington, et al., *Air Force-Wide Needs for STEM*, 4.

- Are current numbers and types of STEM degrees possessed by your officers/civilians sufficient, less than sufficient, or more than sufficient?

- If more degrees are needed, how many and what types of degrees are needed? What requirements will these degrees support?[32]

To the credit of the CFMs and the RAND researchers, the limiting nature of these narrow questions did not prevent broader useful findings and recommendations. For example, as described above, CFMs explained why hard STEM-degree requirements do not make sense for most operations specialties. With this information, the RAND researches echoed the NRC report in recognizing the utility of STEM-cognizance across many career fields. In perhaps their most important recommendation, the RAND team urges consideration of measures and proxies other than STEM degrees to define officer requirements for career fields. They suggest this might entail designating some positions in a functional area as requiring "high-STEM potential" defined as a minimum score on a qualifying test and/or sufficient STEM coursework.[33] Though their examples still focus too narrowly on STEM concerns, the recommendation holds great promise if expanded to focus on the Chief's priorities of creativity, innovation, and critical thinking. That said, providing credit for STEM-cognizance makes particular sense in light of the fact that very few officer specialties require specific degrees.

The *Air Force Officer Classification Directory* (AFOCD) is the official guide to Air Force officer career specialty classification codes. The document describes how personnelists assign a specialty code to each Air Force job and determine the qualifications necessary to perform each job. Each Air Force Specialty Code (AFSC) has target accession rates for

[32] Harrington, et al., *Air Force-Wide Needs for STEM*, 13.
[33] Harrington, et al., *Air Force-Wide Needs for STEM*, 53.

certain academic disciplines. These target accession rates are broken into tiers with an associated percentage of accessions in each. When distributing officer accessions across the education needs of all specialties, tier 1 requirements are considered first until the pool of available accessions with matching education has been exhausted, at which point tier 2 accessions are considered, then tier 3, and so on. When the remaining accessions do not match tier requirements for a specific AFSC, the career field will stop accessing new officers for the year, and the remaining accessions will enter other specialties with more compatible education requirements.[34] The AFOCD further designates the academic program descriptions in each tier as either mandatory, desirable, or permitted.

Only five of 26 line-officer AFSCs have hard mandatory requirements for specific degrees. In all five cases, these are some type of STEM degrees.[35] The specialties include Weather (15W), Civil Engineer (32E and its shredouts), Chemist/Nuclear Chemist (61C), Physicist/Nuclear Engineer (61D), and Developmental Engineer (62E and its shredouts).[36] The specialized nature of each of these positions requires rigid standards. For example, engineers (32E or 62E) have similar requirements as their counterparts in the civilian realm. Additionally, requiring 85 percent (tier 1) of Weather officers to have a meteorology or atmospheric science degree makes sense, as does requiring math and statistics or physical science for the remaining 15 percent at tier 2.[37] Similarly, the Scientific Utilization Field (61XX) encompasses the scientific function associated with analysis, research, and exploratory development in support of Air Force requirements;

---

[34] Headquarters Air Force Personnel Center, *Air Force Officer Classification Directory: The Official Guide to the Air Force Officer Classification Codes (AFOCD),* (San Antonio, TX: Air Force Personnel Center, October 2015), 255.
[35] Line of the Air Force excludes the medical, legal, and chaplain professional corps where licensure or other institutional requirements are levied.
[36] Headquarters Air Force Personnel Center, *AFOCD,* 255-271.
[37] Headquarters Air Force Personnel Center, *AFOCD,* 259.

management in support of highly technical operations and intelligence; the operational assessment of current operations, weapons systems, force structure, doctrine and resources, and lessons learned. The nature of the scientific functional area requires very specific and extensive educational preparation.[38] Other AFSCs prioritize certain STEM degrees as mandatory or desirable without requiring them at all tiers.

Operations Research Analyst (61A) nearly makes the list of AFSCs with hard mandatory STEM requirements since its tier 1 and tier 2 accessions target rates combine for 75 percent mandatory STEM (if quantitative economics is included). However, its tier 3 target at <15 percent includes "other economics" (clearly non-STEM) as permitted. The AFOCD does not address the remaining 10 percent, presumably allowing for other non-STEM degreed accessions.[39] This is interesting since operations research is listed specifically as a STEM academic field in the AFROTC scholarship information and the tier 1 target rate for AFSC 61A is >50 percent and lists a single degree type (operations research) as mandatory.[40] In other words, an AFSC that shares a name with its mandatory tier 1 STEM academic specialty allows one in four accessions to hold non-STEM degrees. There can be little surprise, then, that so few AFSCs have hard requirements.

Operations specialties – rated and non-rated – have no hard mandatory requirements at any tier. For pilots (including those flying Remotely Piloted Aircraft), combat system officers (CSO), and air battle managers an undergraduate degree specializing in physical sciences, mathematics, administration, or management is desirable. The exception is experimental test pilots and CSOs who require a mandatory undergraduate degree specializing in physical sciences, mathematics, or

[38] Headquarters Air Force Personnel Center, *AFOCD,* 209.
[39] Headquarters Air Force Personnel Center, *AFOCD,* 265.
[40] Headquarters Air Force Personnel Center, *AFOCD,* 265.

engineering.[41] These flying-involved career fields are not broken into tiers nor is a target accession rate prescribed in the AFOCD. In 2014, these flying specialties represented a bare majority (50.1 percent) of Air Force officer positions, and as noted earlier fewer than half of these have a STEM degree.[42] Non-STEM-degreed pilots show the same overall technical competency of their STEM-degreed peers. What about other fields that require high levels of technical proficiency, such as nuclear and missile operations, cyber operations, or space operations?

Cyber operations, nuclear and missile operations, and space operations are regarded generally as high-tech, and all three list STEM degrees as mandatory for tier 1. However, the target accessions rates and details of the requirements are quite dissimilar. Tier 1 education requirements for cyber are specific and limited to Computer Science or Computer Engineering with a target accessions rate of 30 percent. Cyber's tier 2 broadens to STEM degrees more generally at a 45 percent target accessions rate and a requirement level of desired. This still allows accession of 5 percent of the cyber operations force with any degree.[43] Nuclear and missile operations requirements tell a different story.

Nuclear engineering and science require deep specialization. ICBM operations do not. The nuclear and missile operations AFSC's tier 1 is STEM mandatory with an accessions target rate of >10 percent. However, the list of acceptable technical degrees greatly expands from the list used by AFROTC. The list of targeted academic degrees gives the impression that any discipline with the words engineering, experimental, or science attached (other than social science) would be included. Even more telling is that tier 2, with an accessions target rate of <90 percent,

---

[41] Headquarters Air Force Personnel Center, *AFOCD,* 25-53.
[42] Harrington, et al., *Air Force-Wide Needs for STEM,* 15.
[43] Headquarters Air Force Personnel Center, *AFOCD*, 260.

simply states "Any Degree."[44] Permitting 90 percent of missileers to be non-STEM renders the tier 1 mandatory requirement essentially meaningless. After the formerly united space and missile career field split, the space-operations functional authority made the decision to bolster the technical requirements for space officers.

The top two tiers for space-operations officers, each with a target accession rate of 40 percent, are STEM-mandatory. The top tier focuses on space-related science and engineering or mathematics, while the second tier opens to a wider variety of technical degrees. However, like the nuclear and missile operations tier 1 list, many of these would not make the AFROTC list of STEM degrees. Tier 3 permits any Bachelor or Master of Science degree for the remaining 20 percent target accession rate.[45] Put another way, space operations academic requirements focus on technical and scientific fields, but for 60 percent of space accessions, STEM-cognizance is sufficient.

Given the AFOCD requirements, the overall need for STEM-degreed accessions is clearly overstated. The number of officer authorizations in those STEM-mandatory AFSCs is rather small in the scheme of the Air Force as a whole. The aforementioned RAND study notes 5,256 STEM-mandatory authorizations.[46] This represents just 10.2 percent of non-medical officer positions.[47] This number is significant, but does not warrant an overall focus on STEM-degreed accessions at the expense of losing well-qualified non-STEM graduates. A true manning crisis in those fields might warrant a measured emphasis. According to the 2010 NRC report, there is some concern with a 14 percent shortfall of field grade officers (263 of 1855 authorizations were unfilled), but that bathtub will fill over time as junior officers promote. Moreover, the study

[44] Headquarters Air Force Personnel Center, *AFOCD*, 257.
[45] Headquarters Air Force Personnel Center, *AFOCD,* 257.
[46] Harrington, et al., *Air Force-Wide Needs for STEM*, 63-69.
[47] Harrington, et al., *Air Force-Wide Needs for STEM*, 15.

notes that overall manning for all five STEM-mandatory officer AFSCs was over 95 percent.[48] There is no crisis.

Summary

The CSAF envisions a future of increasingly complex challenges. Old ways of doing business will not suffice given the dynamic security environment and ongoing fiscal difficulties. There is no engineering solution to these very human problems. The foundation of the Chief's vision and plan for the future rests on human capital. General Welsh recognizes the need to produce decision makers adept in finding creative ways to access the force structure and optimize it to meet mission demands. He calls for arming a generation of leaders with doctrine, history, and experience to provide cross-component expertise.[49] The future requires Airmen who are ready and responsive, demonstrating general qualities such as critical thinking, adaptive behaviors, innovation, creativity, collaboration, social-networking skills, emotional and cognitive intelligence, initiative, and resilience. [50] Unfortunately, the current approach to recruiting that human capital remains mired in old technocratic paradigms.

Officer recruiting efforts unnecessarily over-emphasize STEM degrees. A significant level of STEM-cognizance makes sense for a force that wields so much advanced technology. However, the rationale for limiting AFROTC scholarships to STEM majors fails under scrutiny. The vast majority of officer positions in the Air Force do not require a depth of technical or scientific expertise before commissioning. Robust training provides operators and others the skills they need to build technical competency. Only five of 26 AFSCs have hard mandatory requirements for STEM degrees. The requirements make sense for scientists,

[48] National Research Council, *STEM Workforce Needs*, 35.
[49] Department of the Air Force, *Strategic Master Plan,* 30.
[50] Department of the Air Force, *Future Operating Concept*, 43.

engineers, and meteorologists. However, authorizations in these specialties account for barely 10 percent of the total non-medical officer corps. Moreover, these specialties all enjoy healthy manning levels. Recruiters must still ensure they fill these positions with the best-qualified individuals available, but this does not require limiting the pool of overall accessions to STEM-degree holders.

The diversity of America brings a unique opportunity for the Air Force to draw from a wide talent pool. The CSAF vision calls on the institution to expand the search pattern beyond traditional recruiting pools to ensure the capable, inclusive force the future strategic environment requires. To reap the truly best talent America has to offer, we must eliminate institutional barriers to creating and retaining a diverse team. This means reorienting to the idea that a blend of varied perspectives, cognitive approaches, and critical thought is a combat capability every bit as vital as high-tech hardware. Integrating this idea into all aspects of our operations requires individuals with demonstrated potential for creativity, innovation, and critical thinking. The next three chapters address each of these habits of mind and what they mean for the profession of arms.

Chapter 2

CREATIVITY AND THE PROFESSION OF ARMS

Creative responses are expected in our organizations… because old ways don't work anymore and ready-made solutions often don't solve the problem anyway. We need to be creative to break down worn-out mind-sets and paradigms, search for new responses, and brave new business landscapes.

-- Lynne C. Levesque
Breakthrough Creativity

Creativity is one of three attributes that the CSAF identifies as a critical combat capability for the Air Force. Moreover, creativity undergirds the other two, innovation and critical thinking. It is important, then, to understand just what creativity is and why it matters. This chapter explores creativity – what it is, how it works, and what it means to the profession of arms.

Conceptualizing Creativity

Definitions of the term creativity come with several layers. Some focus on the process of producing something or some idea. Others focus on the product or outcome of that process. For many, the essence of creativity is simply the ability to perceive and think in original and novel ways.[1] For others, novelty is not enough – the idea or thing also must be useful. Neuropsychologist Rex Jung notes the dynamic interplay of novelty and usefulness: "If something is just novel, it could be useless. It could be the word salad of a patient with schizophrenia. That's novel, but it's not particularly useful within a given context and utility — [but] mere utility is not enough. It has to be something new. It has to be useful. It has to be also within a social context so that novelty and usefulness

[1] Nancy C. Andreasan, *The Creating Brain: The Neuroscience of Genius* (New York, NY: Dana Press, 2005), 179.

might be in play, but within a given social context."[2] This adds another layer to our developing definition of creativity – contextual constraints.

Novelty within a given domain can take different forms. The novel idea or task may reiterate a known concept in a new way; move a field forward along its current trajectory; move a field forward in a new direction; or lead to the integration of diverse ideas or trends within a field.[3] The context of a particular domain bounds creativity. Bizarre or irrelevant ideas, though novel, are not creative ideas because they violate task constraints and are thereby not useful. Contextual factors will determine which factor has precedence. For example, the field of art may emphasize novelty, where science or business may weigh constraint satisfaction more heavily.[4] Adding to our definition then, creativity is the capacity to produce novel, useful work that meets contextual constraints of a given domain.

Popular understandings of what constitutes creativity often simply juxtapose creativity with more mundane or technical activity. A landscape designer who creates a beautiful water feature for a country club golf course is considered creative while an irrigation specialist who designs and builds a system to water crops in a farmer's field is not. The two work in a similar medium, use similar tools, and overcome similar challenges to make the water flow correctly, but one primarily concerns himself or herself with aesthetics and the other almost solely with function. Put another way, one practices art, the other engineering. Thinking in these dichotomous terms, however, is a rather recent development.

---

[2] Rex Jung, "Creativity and the Everyday Brain," interview by Krista Tippet, *On Being*, 22 March 2012. Transcript, http://www.onbeing.org/program/creativity-and-everyday-brain/transcript/1882

[3] Todd Lubart and Jacues-Henri Guignard, "The Generality-Specificity of Creativity: A Multivariate Approach" in *Creativity: From Potential to Realization*, ed. Robert J. Sternberg, et al. (Washington, DC: American Psychological Association, 2004), 43-44.

[4] Lubart and Guignard, "The Generality-Specificity of Creativity," 44.

Arts and sciences were not always considered different disciplines. What we now call art has existed for 35,000 years in various forms, such as cave-wall painting, sculpture, jewelry, and the like. Ancient artifacts certainly served purposes other than just aesthetics (e.g., historical records, religious fetishes, etc.), but we readily see them as art – as something creative. Science, as we understand the term, has existed for only around 4,000 years.[5] In the human quest for understanding and explaining the world around us, science did not supplant art; rather the two became complements to one another.

Ancient polymaths like Plato and Aristotle did not separate mathematics and astronomy from the logic and aesthetics of philosophy. Centuries later, Michelangelo, Leonardo DaVinci, and their contemporaries likewise saw no boundaries between art and science. Both Michelangelo and DaVinci were accomplished visual artists, mathematicians, and engineers. Later, their polymathic accomplishments gave rise to the term "Renaissance man" to describe someone demonstrating acumen across a spectrum of endeavors. The fact that someone coined such a specific term around 1908 indicates that some time prior to this the masses had already accepted a distinction between art and science.[6] Since this paper examines the relative merits of STEM versus liberal-arts education in preparing future Air Force officers, let us explore creativity in these terms.

People often see STEM and the arts as having opposite characteristics: objective versus subjective; logical versus intuitive; analytical versus sensual; reproducible versus unique; useful versus frivolous.[7] The first four of these dichotomies ring true in many ways. However, the last, laden with value judgment, shows a bias that is

---

[5] David A. Sousa and Tom Pilecki, *From STEM to STEAM: Using Brain-Compatible Strategies to Integrate the Arts* (Thousand Oaks, CA: Corwin, 2013), 9-10.
[6] *Online Etymological Dictionary*. s.v. "Renaissance man," accessed 29 February 2016, http://www.etymonline.com/index.php?search=Renaissance+man.
[7] Sousa and Pilecki, *STEM to STEAM*, 9.

perhaps partly responsible for the larger national push – and in turn the Air Force's preference – for STEM education. Society places a premium on practical intelligence but often discounts or even ridicules deeper intellectual endeavor. Consider the abundance of jokes about the employability (or rather the supposed lack thereof) of liberal and fine arts majors. This anti-intellectualism is not only problematic but also illogical because the creative and liberal arts do serve practical purposes.

Though creativity and intelligence are certainly distinct, they intersect in interesting ways. Several skills developed through visual and performing-arts education have direct application as scientific tools. Some of these skills are internal or receptive while others are external or expressive. Among the former are drawing on curiosity; observing carefully and accurately; perceiving an object in a different form; thinking spatially (e.g., mentally rotating objects); and perceiving kinesthetically (i.e., how things move). There are also expressive skills developed through practicing the arts, namely the ability to construct meaning and express one's observations accurately; and the ability to work well with others.[8] Each of these skills is an intersection of art and science. This is no surprise when we recognize that scientists and artists use common tools for thinking – observing, imaging, abstracting, pattern recognizing, pattern forming, analogizing, empathizing, dimensional thinking, modeling, playing, transforming, and synthesizing.[9] Indeed, cognitive processes are the root similarity between artistic and scientific activity. In other words, both creativity and intelligence arise in the brain and use similar tools and skills. So why are they different? Interestingly (if perhaps ironically) we must turn to science to learn about creativity.

---

[8] Sousa and Pilecki, *STEM to STEAM*, 11.
[9] Robert and Michele Root-Boorstein, "Artistic Scientists and Scientific Artists: The Link Between Polymath and Creativity" *Creativity: From Potential to Realization*, ed. Robert Sternberg, Elena L. Grigorenko, and Jerome L. Singer (Washington, DC: American Psychological Association, 2004), 138.

How Creativity Works

Brain cells grow new connections in a second wave of production in preadolescence. Then, in adolescence, there is an overproduction of neurons and, almost immediately, their selective elimination begins. Experience and learning drive the pruning of these connections through a "use it or lose it" process. This makes the brain more efficient.[10] Adolescent brains are flexible and adaptable with an enormous potential for change in the late teen years. Choices determine the qualities of the brain. By concentrating on math, music, or sports, the brain will incorporate these activities in the form of neuronal circuits. This is important because these are the brain cells and connections that will survive as people move into adulthood.[11] This is another reason for focusing on pre-commissioning education in this study. Undergraduate study exercises neuronal circuits at the optimal point of development, thereby establishing particular habits of mind by developing habitual processes in the brain.

So called Left-Brain/Right Brain hemispheric asymmetry is a popular explanation for differing degrees of creativity. Hemispheric asymmetry is the idea that different areas of the brain specialize in certain types of tasks and that such asymmetries are present at or near birth.[12] One view of the differences between the hemispheres is that the left brain operates in a logical, analytical manner while the right brain works in a Gestalt, synthetic fashion.[13] A related concept is the sequential-simultaneous distinction. This reflects a theoretical model holding that the left hemisphere is tasked to deal with rapid changes in time and to analyze stimuli in terms of details and features. The right

---

[10] Richard Restak, *The Secret Life of the Brain*, (New York, NY: The Dana Press and Joseph Henry Press, 2001), 72.
[11] Restak, *Secret Life of the Brain*, 77.
[12] Sally P. Springer and Georg Deutsch, *Left Brain, Right Brain: Perspectives from Cognitive Neuroscience*, 5th ed. (New York, NY: W.H. Freeman and Company, 1998), 263.
[13] Springer and Deutsch, *Left Brain, Right Brain*, 292.

hemisphere, on the other hand, deals with simultaneous relationships and with the more global properties of patterns.[14]

Neuropsychologists Elkhonon Goldberg and Louis Costa insert a contextual aspect to hemispheric differences. They contend that such differences are a function of the applicability of an individual's existing experience and knowledge to ongoing events. This hypothesis states that the left hemisphere specializes in processing well-routinized codes, such as the motoric aspects of language production, and that the right hemisphere is crucial for situations that are more novel. As a task becomes more familiar through either repetition or perhaps subsequent recognition of an analogous relation to something already known, the hemisphere involved will shift.[15] This is important as it shows that cognitive styles can change over time and across contexts. This, in turn, implies that exercising those styles can develop them.

Hemispheric asymmetry as an explanation of creativity does not satisfy all brain scientists. Rex Jung researches the relationship between intelligence and creativity. After studying intelligence for a number of years, Jung became aware that the intellectual capacities of the brain did not tell a complete story. He recognized that other human capacities, particularly creative capacity, were important in understanding the complexities of the human mind. Though both are rooted in cognitive processes, creativity is something other than intelligence in that different brain networks are involved. Additionally, the way those brain networks are engaged is different also.

Studying intelligence, Jung noted that the back part of the brain and the front part of the brain are integrated in a way that allows intelligence to work well. Greater cortical thickness, more neurons, higher connectivity between those neurons, and more biochemicals

[14] Springer and Deutsch, *Left Brain, Right Brain*, 292.
[15] Cited in Springer and Deutsch, *Left Brain, Right Brain*, 293.

subserving those neurons are almost invariably better for intelligence.[16] Creativity, however, is not a product of intellect; or rather high intelligence is neither a crucial nor necessary ingredient for creativity. In World War II, American air forces sought to identify fighter pilots who could get out of jams in unorthodox ways rather than simply bail out at the earliest sign of trouble. The military initially used conventional IQ tests to identify candidates, but soon realized high IQ scores had no correlation to inventiveness; so turned to measures that were more anecdotal.[17] Lacking current CT or PET-scan imaging technology, they did not know why, but they recognized that creativity works differently from intelligence.

Current science indicates that the powerful organizing activity of the frontal lobes of the brain is temporarily "down regulated" or diminished during periods of creative cognition. This "transient hypofrontality" allows different networks in the brain freer interplay, so that disparate ideas literally can link together more readily. Jung uses a driving analogy to explain. He describes intelligence as a superhighway in the brain that allows you to get from Point A to Point B quickly and directly. With creativity, Jung pictures a slower, more meandering process where you take the side roads and even dirt roads to get where you put the ideas together.[18] This analogy describes the contrast between convergent and divergent thinking.

Convergent and divergent thinking are two different ways of looking at the world. Specifically, they are the polar ends of a spectrum of approaches to solving problems and answering questions. A convergent thinker sees a limited, predetermined number of options. By contrast, a divergent thinker is always looking for more options. The

---

[16] Rex Jung, "Creativity and the Everyday Brain."
[17] Ulrich Kraft, "Unleashing Creativity" *Best of the Brain from Scientific American: Mind, Matter, and Tomorrow's Brain* (New York, NY: Dana Press, 2007), 12.
[18] Rex Jung, "Creativity and the Everyday Brain."

terms have held up since Joy Paul Guilford first proposed in the 1940s that the difference between convergent and divergent thinking is the crucial variable in determining creative ability.[19] This difference is really one of orientation.

The convergent thinker is oriented from the *outside* in. He or she brings together material from various sources to solve a problem or answer a question. Convergent thinking involves piecing together relevant facts, data, and procedures to arrive at – or converge on – a single right answer.[20] This type of thinking primarily involves simple recall of information, relating it directly to the problem at hand, and executing a solution. These actions correspond to the lower levels of Bloom's Taxonomy of Learning: remember, understand, and apply.[21] As such, convergent thinking works best for well-defined problems that have definite solutions.

The divergent thinker is oriented from the inside out. He or she generates several ideas about possible ways to solve a problem, often by breaking it apart into its "divergent" parts and looking for new insights into the problem. This process moves problem solvers to the higher levels of Bloom's Taxonomy: analyze, evaluate, and create. Thus, divergent thinkers are able to draw connections among ideas, compare and critique possible solutions, and conjecture possible second- and third-order effects.[22] This capacity is particularly useful in dealing with poorly defined problems that have multifaceted solutions, an apt

[19] Ulrich, "Unleashing Creativity," 12.
[20] Sousa and Pilecki, *STEM to STEAM*, 41.
[21] Patricia Armstrong, "Bloom's Taxonomy" Vanderbilt University Center for Teaching, accessed 27 March 2016, https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/#2001. Bloom's original taxonomy described levels of thinking as nouns (knowledge, comprehension, application, analysis, synthesis, evaluation). In 2001, a group of cognitive psychologists, curriculum theorists and instructional researchers, and testing and assessment specialists published a revision of Bloom's Taxonomy using action words to describe the cognitive processes by which thinkers encounter and work with knowledge. These revised terms are used here.
[22] Armstrong, "Bloom's Taxonomy."

description of the increasingly complex operating environment.[23] Both convergent and divergent thinking have their place. In fact, they are most effective when used together.

Creativity entails the ability to use divergent thinking to probe deeply and find alternative solutions not previously considered.[24] In other words, divergent thinking produces ideas that are novel and useful. Recall, though, the third part of our working definition of creativity – within contextual constraints. Bounding the novel and useful ideas within a given domain is a function of convergent thinking. To be truly creative requires fitting both forms together. This is reminiscent of Nobel laureate Christiane Nusslein-Volhard likening her embryological work to assembling pieces of a jigsaw puzzle: "The most important thing is not any one particular piece, but finding enough pieces and enough connections between them to recognize the whole picture."[25] The brain's role in creativity is complex. The role of creativity in facing a complex and changing operational environment is no less so.

Applying Creativity in the Profession of Arms

For creativity to matter in this study (and in the Chief's vision), it must be applicable to the profession of arms. Ideas about the fungibility of creativity differ. The narrower the view of what creativity is, the less likely it is to be transferable from one field of practice to another. Conversely, the broader the view of what constitutes creativity, the more accepting of its transferability. This is more than an academic question. If creativity is indeed fungible, then finding ways to develop it in one domain can pay dividends in others. This matters in the profession of arms because it is a unique domain the tenets of which generally are not

[23] Sousa and Pilecki, *STEM to STEAM*, 41-42.
[24] Sousa and Pilecki, *STEM to STEAM*, 24.
[25] Cited in Robert and Michele Root-Boorstein, "Artistic Scientists and Scientific Artists," 140.

taught in elementary, secondary, or post-secondary schools with the exception of the service academies. Realizing the CSAF's vision of mentally agile airmen is impossible if creativity is simply innate and bound by domain.

Domain-specific theory holds that creativity is not transferable. The argument is that expertise in a given field affords individuals an enormous knowledge base upon which to draw for being creative in that particular field. That knowledge, the theory contends, would not be helpful in most other domains of work, and therefore not support creativity in them.[26] This is the idea of "Big-C" creativity where significant achievements have a domain-altering impact in their given field, versus a more generalized personal (or "small-c") creativity that may cut across domains, but never amounts to grandiose achievements.[27] Common examples are the master works of renowned artists, but "Big-C" creativity is also possible in fields other than the arts. Louis Pasteur's work in germ theory certainly qualifies as novel, useful, and domain-altering. Einstein's work with energy and relativity changed the domain of physics. By doing so, he also forever altered the domain of war and international politics by enabling others to develop atomic weapons. Even if creativity itself is domain-specific, its product often is not.

Domain-generality theory argues that creativity can and often does cross over and interacts among several domains. Creativity researcher Robert Sternberg notes that substantial empirical evidence from personality- and abilities-based study approaches support this.[28] Robert and Michele Root-Bernstein argue that creativity may often arise from taking ideas from one field and transferring them to another, and that mastering one field is a good foundation for mastering another. From

---

[26] Robert Sternberg, Elena L. Grigorenko, and Jerome L. Singer, eds. *Creativity: From Potential to Realization*, (Washington, DC: American Psychological Association, 2004, ix.
[27] Robert and Michele Root-Boorstein, "Artistic Scientists and Scientific Artists, 128.
[28] Robert J. Sternberg, et al., ed., *Creativity: From Potential to Realization*, ix.

their study of polymath, the Root-Bernsteins demonstrate that creative people integrate apparently disparate skills, talents, and activities into a synergistic whole. Creativity stems from an ability to recognize useful points of contact and analogous skills among an apparently diverse set of interests.[29] Again, examplars like DaVinci and Michaelangelo whose great works cross the domains of art and science clearly show that domain-generality happens. It may or may not be rare, but it clearly is possible if the right cognitive competencies are developed.

In his book, *The Arts and the Creation of Mind*, researcher Eliot Eisner identifies several cognitive competencies developed by training in the arts, but applicable across domains.[30] The first competency is perceiving relationships. Recognizing that a given thing or situation has constituent parts prevents one-dimensional thinking. Comprehending how parts influence each other and interact to form a whole system, and in turn, how a particular system affects every other system, is essential to understanding a complex operational environment. Related to the first is an attention not only to detail, but also to nuance. Knowing that small differences can have large effects is critical for decision makers in any field, particularly in the military where lives are literally on the line. Appreciating nuance also enables the use of allusion, analogy, and metaphor to help explain complex or abstract concepts.

A third cognitive competency identified by Eisner is a perspective that problems can have multiple solutions or that questions can have multiple answers. In more technical or concrete disciplines, like arithmetic, students strive to find the one correct answer. The abstract exploratory nature of the arts encourages looking for alternatives. In a military context, this enables alternate courses of action (COAs). Related to this is a fourth competency, the ability to shift goals in process.

---

[29] Robert and Michele Root-Bernstein, “Artistic Scientists and Scientific Artists,” 144.
[30] Eliot Eisner, *The Arts and the Creation of Mind*, (New Haven, CT: Yale University Press, 2002), 75-90.

Moltke's adage that no plan survives first contact with an enemy comes to mind. Planning branches and sequels to a particular COA can provide flexibility when new information comes to light or the situation on the ground changes. Of course, branches and sequels will not eliminate the need for flexibility since they face the same challenge of unpredictability.

Using the imagination as a source of context is a fifth cognitive competency derived from arts education. Finding oneself in an unfamiliar situation can be exhilarating or terrifying. The difference comes from recognizing whether the context is threatening or not. When first arriving in a new theater of operations, a soldier or Airman lacks specific expertise about the environment. Drawing on similar experiences enables using imagination to fill in the gaps to assess the new situation. This involves developing personal judgment, which comes from a sixth cognitive competency, the permission to make decisions in the absence of a specific rule. Producing novel art involves exploring the heretofore unknown. In a military context, the ability to apply judgment is an essential skill for a military officer. Doctrine provides a framework for making decisions, but infinite possibilities render detailed formulae impractical if not impossible. Rules of engagement (ROE) set boundaries on acceptable actions, but within those bounds, possible responses abound. Judgment is key to choosing the best one.

A seventh cognitive competency developed through arts education is the acceptance of operating within constraints. No system, whether linguistic, numeral, visual, or auditory covers every purpose. The arts allow a chance to use constraints of a medium to invent ways to exploit those constraints productively. The discussion of doctrine and ROE above provides a military example of this competency as well. Related is the final cognitive competency, the ability to frame the world in fresh ways. In artistic terms, this is seeing the world from an aesthetic perspective. In military terms, it is understanding that others, whether armed adversary, local power broker, or non-combatant caught in the

crossfire of a conflict, have a different perspective. This is vital to avoid mirror-imaging and better to predict how that other might act or react to a given action. These cognitive competencies are the mechanism that make creativity domain-general rather than domain-specific.

Another approach to understanding the applicability of creativity arises from a systems perspective. The systems model proposes that we can only observe creativity in the interrelations within a system consisting of three main elements – the domain, the field, and the individual. The domain consists of a set of rules, procedures, and understood instructions for action. Art is such a domain with the various styles and schools considered sub-domains. The field includes all the individuals who act as gatekeepers to the domain. In the art-world example, the field consists of art historians, critics, dealers, collectors and the artists themselves. Collectively, the field essentially conducts peer-review and decides whether to add a new idea or product into the domain. The final element in the systems model is the individual who exercises creativity in an attempt to change the rules, procedures, or instruction of the domain.[31] Examples of avant-garde innovators outside the arts include such technology luminaries as Steve Jobs and Elon Musk. The systems model is useful for examining creativity's role in the profession of arms.

The elements of the systems model of creativity are readily apparent in the context of war and the profession of arms. Military practitioners readily recognize doctrine, ROE, and tactics, techniques, and procedures (TTP) as a "set of rules, procedures, and understood instructions for action." The domain also consists of the larger political context and objectives (national and operational) of a particular situation. The field is the military and political leadership that exercise

[31] Sami Abuhamedh and Mihaly Csikszentmihalyi, "The Artistic Personality: A Systems Perspective," in *Creativity: From Potential to Realization*, 31-33.

control over the domain. The third element of the systems model of creativity is the individual who challenges the accepted way of doing business. In the profession of arms, this element is often a maverick leader. The Berlin Airlift provides an interesting example to demonstrate this construct.

The Berlin Airlift was one of the earliest military interventions, albeit a non-violent one, of the Cold War. The Soviets' opposition to establishing a separate state of West Germany resulted in a series of crises in 1948. In February, the Soviet coup in Czechoslovakia shocked the western powers and accelerated western plans to consolidate their German occupation zones, form an independent state, and establish a currency beyond the control of the Soviets. As relations soured, the Soviet military governor in April ordered travel restrictions between the American, British, and French zones and Soviet sectors in Berlin, eventually establishing a full blockade of the city in June.[32] This political context comprises part of the domain in this system. Objectives are another aspect of the domain.

Avoiding general war with the Soviets became the overarching national political objective for the United States. Stabilizing Europe and the Pacific was the first order of business for the victors of the Second World War. Even during the brief American monopoly in atomic weapons, fighting against the Soviet war machine was in no one's interest with a Soviet army numbering between one-half and one million men in Germany alone.[33] The only alternative to answer communist aggression was an atomic blitz, an option that President Truman did not relish.[34] The risks from such a war later would mushroom when the Soviets detonated their first atomic device at the end of August 1949.

[32] Roger G. Miller, *To Save a City: The Berlin Airlift 1948-1949* (College Station, TX: Texas A&M University Press, 2000), 16-20, 32.
[33] Miller, *To Save a City*, 30.
[34] Eric Schlosser, *Command and Control: Nuclear Weapons, the Damascus Accident, and the Illusion of Safety*, (New York, NY: Penguin Press, 2013), 85.

With the threat of a spiraling arms race, avoiding such a disaster colored every move the United States made throughout the decades of the Cold War.

The operational objectives of the Berlin Airlift aligned closely with overarching national objectives. The immediate objective of the airlift was to provide life-sustaining food, fuel, and consumer goods to not only the western powers' garrisons, but also to the people of Berlin cut off from overland transportation routes. Never intended as a long-term solution, the operation was a stopgap measure to buy time while seeking a diplomatic solution to the crisis of the Soviet blockade.[35] The secondary objective was in direct support of the national objective of avoiding a shooting war. Note that political and military leaders perceived relationships, appreciated nuance, recognized the possibility of different solutions, and shifted goals in process. Eisner's creative cognitive competencies were heavily involved in understanding and defining the political context and objectives.

Doctrine is the last aspect of domain to examine. Having gained independence as a separate service only the year prior, the Air Force had not published official doctrine, but the perceived success of strategic bombing in World War II still dominated airpower thinking. Downplaying success in both tactical support to ground forces and effective use of airlift and air mobility, the central tenet of Air Force leaders held that strategic bombing, especially with nuclear weapons, would be decisive and thus built their force around the strategic bomber.[36] In other words, no doctrine existed to support the type of operation that became the Berlin Airlift. Summarizing the domain in which the Berlin Airlift took place: a political context of conflict between major powers existed; national and operational objectives entailed supporting Berlin while

[35] Miller, *To Save a City*, 34.
[36] Col Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945-1982*, (Maxwell AFB, AL: Air University Press, 1998), 43.

avoiding war with the Soviets; and existing doctrine was limited to strategic attack and therefore was inconsistent with the objectives.

General Lucius D. Clay, the American military governor in Berlin, and Lt. General Curtis LeMay, Commander of United States Air Forces in Europe, represent the military-leadership aspect of the field in our system. Clay was committed to the support of Berlin and held tenaciously to his initial recommendation of an armed convoy to break the blockade by land. LeMay, for his part, planned to support such an attack with strategic bombing attacks on Soviet airfields in Germany.[37] Both stances were consistent with existing doctrine, but risked compromising the political leadership's national objective of avoiding general war. The Truman administration eschewed the call for an armed forcing action along the autobahn and decided to supply the western sectors of the city by air. In the end, this fifteen-month gargantuan effort delivered more than 2.3 million tons of cargo even besting Russia's oldest ally, winter weather. Again, we see the play of Eisner's cognitive competencies such as seeking multiple solutions and acting within constraints. What we have not seen yet, is making decisions in the absence of a specific rule. In fact, the doctrinal mismatch to the president's objectives complicated the situation. This tension in the domain and field created an opening for change.

To their credit, when the Army Secretary and Chief of Staff relayed the president's decision to avoid anything so provocative, Clay and LeMay moved quickly to make supply by air a reality.[38] Recognizing the insuffiency of existing doctrine, LeMay quickly sought the expertise of Major General William H. Tunner, who had great success commanding the airlift and air mobility mission over The Hump of the Himalayas in the China-Burma-India theater of World War II.[39] Tunner's experience

[37] Miller, *To Save a City*, 43.
[38] Miller, *To Save a City*, 44.
[39] Miller, *To Save a City*, 87-89.

and organizational acumen stood in place of doctrine and demonstrated the importance of unified command, trained professionals, and appropriate airframes for the novel use of strategic transportation.[40] Eisner's cognitive competencies of using imagination to derive context and making decisions absent a specific rule enabled a doctrinal surrogacy. This creative approach overcame the tension between doctrine and objectives. In fact, creativity provided effective linking of air forces to national objectives.

As an agent of change, Tunner represents the individual in the systems model of creativity. He developed a novel approach to massive-scale logistics by air and demonstrated that airpower could deliver strategic effects in ways other than bombing. By exercising Eisner's creative cognitive competencies, Tunner essentially created a subdomain of strategic airlift within the existing domain of military airpower. As new challenges arise in the complex security environment of the future, similar mismatches in context and existing doctrine are inevitable. Successfully ameliorating those tensions requires individuals to challenge and change the domain of the current military doctrine and strategic thought. The ability – and propensity – to do so results from a habit of mind that enables cross-domain application of creativity.

Summary

This chapter explored creativity – what it is, how it works, and how it might look in the profession of arms. Creativity is not some ethereal quality peculiar to artists. Indeed, defining creativity as the capacity to produce novel, useful work that meets contextual constraints of a given domain exposes the falseness of the dichotomy between art and science. The two employ similar tools and skills as demonstrated by polymaths like DaVinci and Michaelangelo. Creativity is a cognitive process that

---

[40] Miller, *To Save a City*, 193.

occurs in the human brain. Whether creative pathways move from left to right or front to back, ultimately the creative process is a combination of divergent and convergent thinking. Divergent thinking produces a range of possibilities by looking outward. Convergent thinking then makes sense of the range of possibilities, ensures the chosen solution adheres to contextual constraints, and enables communicating those ideas to others. Thankfully, creativity is a fungible asset. That is to say, creativity in a given field serves as a base from which to develop creative ideas in another. For the profession of arms, this means that liberal arts education develops habits of mind that pay dividends in a military context. The next chapter turns to a more tangible type of creativity and another of the CSAF's priorities, innovation.

Chapter 3

INNOVATION AND THE PROFESSION OF ARMS

The challenge comes when the standard response is applied to non-standard problems in a complex and ambiguous environment. Predictably, the standard response provides an ineffective solution.

- Charles D. Allen

True revolutions happen, above all, in the minds of men.

- Ralph Peters

The CSAF identifies innovation as a critical combat capability for the Air Force. Rooted in its precursor, creativity, innovation moves organizations forward. Also like creativity, however, the term innovation means different things to different people. It is important, then to understand just what innovation is and why it matters. This chapter explores innovation – what it is, how it works, and what it means to the profession of arms.

Conceptualizing Innovation

The term *innovation* is grossly overused and therefore not well understood. Like creativity, people define innovation in different ways. Some treat it as a process, others as the product of that process. Others have argued that a precise definition is unnecessary because "we know what innovation is."[1] However, we use the term so ubiquitously today that we cannot be sure we are talking about the same thing. When words represent some indistinct idea, they are prone to misunderstanding and distortion, often with significant consequences. Precise definitions prevent careless use of terms from confusing issues and clouding judgment. Therefore, we turn now to defining innovation.

[1] Brig Gen David E. Fastabend and Col Robert H. Simpson, "The Imperative for a Culture of Innovation in the U.S. Army: Adapt or Die," *Army* 54, no.2 (February 2004), 16.

At its simplest, innovation is defined as "a new idea, device, or method."[2] This suggests that innovation is a noun – a product rather than a process. The term "device" connotes a tool or piece of technology. This could be anything from a scale or abacus to a laser range-finder or computer tablet. Stepping from technological example of innovation to a technological definition, however, is problematic. Too often, people conflate technological advances with innovation. Technology often plays a part in innovation, but they are not the same thing.

For too long, the Air Force treated technological artifacts (e.g., specific platforms, precision munitions, etc.) as its raison d'être. Worse, the institution too often considered these artifacts as a panacea. The strategic bomber promised a quick end to the Second World War. The nuclear weapon promised the ultimate deterrent and a guaranteed win over those who did not have them. Fast, multirole jets promised efficiency and effectiveness above and on the battlefield. Persistent overhead ISR promised complete situational awareness in real time. Thus, the service succumbed to the allure of what Lt Col Steven A. Fino described as "technological exuberance and the potential trap of an unchallenged technological trajectory."[3] Each of the aforementioned innovations fell short of their full promise when adversaries adapted their own technology or tactics – or both. In other words, the enemy innovated. With this change to the verb form, our definition of innovation moves from a thing or product to an action.

Innovating involves doing something. Moreover, it involves doing something novel. As with creativity, however, novelty is not enough. US Army Major Dan Mauer, writing for the United States Military Academy's Modern War Institute discusses different action-oriented definitions of

---

[2] Col Thomas M. Williams, "Understanding Innovation," *Military Review* 89, no. 4 (July-August, 2009), 60.

[3] Steven A. Fino, *"All the Missiles Work": Technological Dislocations and Military Innovation; A Case Study in US Air Force Air-to-Air Armament, Post-World War II through Operation Rolling Thunder*, Drew Paper No. 12, (Maxwell AFB, AL: 2015), 126.

innovation in a military context. Mauer notes that RAND defines innovation as the "development of new warfighting concepts and/or new means of integrating technology." Similarly, the US Army defines innovation as "the action or process of introducing something new, or creating new uses for existing designs."[4] Adopting a new method is to give up doing one thing and changing to do something else, presumably because it is better in some way. Perhaps the new activity is cheaper, faster, less risky, or more effective in the given context.[5] A close examination of the RAND and Army definitions of innovation demonstrates commonality with all three aspects of our definition of creativity from the previous chapter: novel, useful, and contextually constrained.

Creativity cuts across domains because creative people – both artistic and scientific – use common tools: their imagining abilities, analogic and abstract thought, mental modeling, and sharp observation of the world around them. While the products of the arts and sciences are different in both aspect and purpose, the processes used by both to forge innovations are extremely similar.[6] While innovation often involves technology, it is really about a habit of mind. Innovators try as much as possible to avoid being overly constrained by the conservative nature of their overlearned schemata and scripts.[7] Still, creativity and innovation, while intimately connected, are not synonymous.

---

[4] Both definitions cited in Maj Dan Mauer, "The 'Inception' Theory of Military Innovation," *Modern War Institute* (blog), 29 March 2016, http://www.modernwarinstitue.org/inception-theory-military-innovation/.
[5] Maurer, "The 'Inception' Theory of Military Innovation."
[6] Robert Root-Bernstein and Michele Root-Bernstein, "Artistic Scientists and Scientific Artists: The Link Between Polymath and Creativity," *Creativity: From Potential to Realization*, ed. Robert J. Sternberg, Elena L. Grigorenko, and Jerome L. Singer, 1st ed., (Washington, DC: American Psychological Association, 2001), 127.
[7] Jerome Singer, "Concluding Comments: Crossover Creativity or Domain Specificity?" *Creativity: From Potential to Realization*, ed. Robert J. Sternberg, Elena L. Grigorenko, and Jerome L. Singer, 1st ed., (Washington, DC: American Psychological Association, 2001), 202.

Whereas creativity involves the *generation* of new and useful ideas, innovation is the *adoption* of those new and useful ideas by people in a community or an organization.[8] Until a community of users accepts the novel means, no real innovation occurs. The centuries-long story of how measures and the numerals to express them normalized and standardized across civilizations shows how long a process of innovation can take. Consensus-building takes time and effort. Innovation is not a discrete event or individual action, but rather a process. Specific intellectual abilities that are important for innovation include: the synthetic ability to define and represent problems in new ways; the analytic ability to recognize which ideas are worth pursuing; and the practical ability to persuade others of the value of the new work.[9] This requires innovators to be tenacious, persistent, focused, and open to experience.[10] Adding to our developing definition then, innovation is the process of adopting a new idea, device, or method that is useful in a particular context.

Despite caricatures to the contrary, organizations rarely change simply for the sake of change. Bureaucratic inertia generally favors the status quo. Barry R. Posen argues that organizations, particularly military bureaucracies, seldom innovate of their own accord because change brings uncertainty, and organizations abhor uncertainty.[11] What, then, drives the pursuit of change? Posen argues that extrinsic structural, political, and hierarchical factors compel innovation. Stephen Peter Rosen, on the other hand, sees intrinsic motivations for

[8] Lynne C. Levesque, *Breakthrough Creativity: Achieving Top Performance Using the Eight Creative Talents* (Palo Alto, CA: Davies-Black Publishing, 2001), 5.
[9] Todd Lubart and Jacques-Henri Guinard, "The Generality-Specificity of Creativity: A Multidisciplinary Approach," *Creativity: From Potential to Realization*, (Washington, DC: American Psychological Association, 2004), 46.
[10] Sheila J. Henderson, "Inventors: The Ordinary Genius Next Door," *Creativity: From Potential to Realization*, ed. Robert J. Sternberg, Elena L. Grigorenko, and Jerome L. Singer, 1st ed., (Washington, DC: American Psychological Association, 2001), 120.
[11] Barry R. Posen, *The Sources of Military Doctrine: France, Britain, and Germany Between the Wars*, (Ithaca, NY: Cornell University Press, 1984), 224.

organizational innovation. That is to say, the organization is not compelled from outside, but has a choice. Arguably, however, the motivations he identifies are still responses to events or possibilities in which the organization finds itself. Writing specifically about military innovation, Rosen acknowledges the role of rivalry among subcultures within organizations, but argues that recognition of inappropriate goals and anticipation of the future drive change.[12] Put another way, organizations undertake innovation to solve problems and to seek advantage.

Problem-solving is a common impetus for innovation. Professor Rosabeth Moss Kantor explains that innovation is more than doing an assigned task faster, or even better. One can manage such tasks with existing ways and means. Something truly innovative involves problematic situations that threaten disruption. As such, problems require creative approaches, or novel ways, to frame and address the matter at hand.[13] An orientation toward problem-solving distinguishes innovators from other types of creative people. Of course, the first step in solving a problem is identifying it. Problem-*finding* is a critical cognitive process among all people and central to the process of successful innovators.[14] Many problems present themselves in obvious ways, like those in puzzle books and school exams. Others are not so obvious and require active efforts of discovery to help define them.[15] Methods of problem-discovery include searching for counterexamples instead of supporting instances and searching for alternative

---

[12] Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military*, (Ithaca, NY: Cornell University Press, 1991), 52.
[13] Cited in Williams, "Understanding Innovation," 60.
[14] Henderson, "Ordinary Genius," 107.
[15] John Hayes, "Cognitive Processes in Creative Arts," *Creativity: Being Usefully Innovative in Solving Diverse Problems*, ed. Stuart Nagel, (Huntington, NY: Nova Science Publishers, Inc., 2000), 40.

interpretations.[16] Such alternatives identify problems, but also might suggest a route to possible solutions.

Forecasting possible futures can suggest ways to seek advantage. Contemporary tech companies do this regularly. Apple successfully wagered on the mobile revolution when it introduced the iPhone. No real problem needed solving. Instead, Steve Jobs and his company capitalized on the possibilities enabled by miniaturization and the growth of terrestrial telecommunication networks. Regarding military innovation, Rosen suggests, particularly in peacetime, change comes from how military communities evaluate the future. He discounts the possibility that they base this evaluation on the particular capabilities or tendencies of a given potential adversary. Rosen contends that these things are too unclear, if not wholly unknowable, to serve as a basis for important predictions and innovation decisions. Rather, he looks more generally to predicted changes in the character of war and the structure of the international environment.[17] Leaders will then change in ways that provide advantage in the anticipated conditions. Problem solving and advantage-seeking add the final dimension to our definition of innovation.

The foregoing discussion demonstrated that, at its most basic, innovation is about change. Considered as a noun, innovation is a new idea, device, or method. However, these things do not simply generate themselves. Innovating requires action. Therefore, we added process along with usefulness and contextual compliance to the definition. Then we acknowledged that idea-generation is necessary but insufficient for true innovation. General acceptance by a community of practice is necessary. Finally, by examining what drives innovation, we added problem-solving and advantage-seeking. This brings us to a workable

[16] Hayes, "Cognitive Processes in Creative Arts," 58.
[17] Rosen, *Winning the Next War*, 251.

definition that will guide the remainder of this chapter and the paper in its entirety. Innovation is the development and application of novel concepts, technologies, or methods to solve problems or deliver a decisive advantage in a given social context.

To thoroughly understand the concept and what it means to the profession of arms, one must recognize that innovation is a social phenomenon. The bulk of the literature, however, focuses on technological innovation. The next section of this chapter will examine two of the most prominent schools of thought on the social nature of technological development.

How Innovation Works

Two of the primary schools of thought on technological innovation are the social constructivist theorists and the large technical systems theorists. Both schools include organizations, their activities and processes, and the resultant knowledge itself in considering technological development and innovation. This approach recognizes that disparate stakeholders have varied needs and interpretations of a problem and its solution. Put another way by Thomas P. Hughes, large technical systems succeed by integrating technical, social, economic, and political aspects.[18] Both schools recognize that technological development is not linear or sequential, but rather multi-directional with overlapping phases and backtracking as alternate solutions are proposed and tested. They differ, however, in important respects. Particularly, social constructivists and large technical system theorists look differently at who guides development of a new technological innovation.

Society itself is the guiding force of innovation for social constructivist theorists. In their example, Trevor Pinch and Wiebe E.

---

[18] Thomas P. Hughes, *Rescuing Prometheus: Four Monumental Projects that Changed the Modern World*, (New York, NY: Vintage Books, 1998), 14-15.

Bijker show that the invention of the safety bicycle was not an isolated or instantaneous event. Rather, different stakeholders identified particular problems with an existing iteration of the technological artifact over 19 years.[19] Moreover, these relevant social groups each proposed and implemented separate solutions to their particular problem. Other social groups discovered and addressed subsequent problems until a generally agreed-upon form stabilized.[20] Today we refer to this type of process as crowdsourcing. Improved feedback mechanisms (e.g., social media) make crowdsourcing very effective in developing items with broad applications. Very specific technical projects, however, are better understood through large technical systems theory.

System builders are the guiding force of innovation for large technical systems theorists. Hughes describes General Bernard Schriever as the system builder for the development of the Atlas intercontinental ballistic missile (ICBM).[21] Schriever effectively maneuvered across disciplinary and functional boundaries to develop a complex system of complex systems. These are not only the technical systems of the missile itself (e.g., propulsion, guidance, etc.), but social systems as well (e.g., funding streams, political advocacy, etc.).[22] The use of project groups was similar to the relevant social groups previously discussed. However, project groups formalized the negotiation and compromise necessary to achieve the ends of the project – integration into a working ICBM.[23] Schriever became what John Law calls a "heterogeneous engineer" in order to overcome the institutional inertia of an Air Force that stubbornly held to not just the hardware, but the very

---

[19] Trevor Pinch and Wiebe E. Bijker, "The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other," *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, ed. Wiebe E. Bijker, Thomas P. Hughes, and Trevor Pinch, (Cambridge, MA: The MIT Press, 2012), 30.
[20] Pinch and Bijker, "The Social Construction of Facts and Artifacts," 37-39.
[21] Hughes, *Rescuing Prometheus*, 93.
[22] Hughes, *Rescuing Prometheus*, 102-107.
[23] Hughes, *Rescuing Prometheus*, 115.

idea of the strategic bomber.[24] This shows the importance of a champion for large technical projects.

While the ICBM is a military weapon system, its development is presented here not as a military innovation, but simply as representative of a complex technical undertaking. The next section will explore more specifically what innovation means to the profession of arms. First is a historical examination of the relationship between strategic thought and technology. This is followed by addressing innovation as envisioned in the CSAF's *Strategic Master Plan.*

Applying Innovation in the Profession of Arms

The interwar period was a time of great innovation in military hardware and thought. The introduction of the airplane over the battlefields of World War I spurred airpower theorists to explore the possibilities of this revolutionary technology. Industrial-web theory led to a strategy of long-range strategic bombing as a quick and cost-effective alternative to the bloody grind that land warfare had become. This new strategy in turn drove more technological innovation in airframes and weapons delivery. Airpower leaders of the day fell victim to the risks that a mutually reinforcing relationship can bring when unbalanced, but found success when they did not favor strategy or technology over the other. The lesson to carry forward is keeping strategy and technology in proper balance so they do not hold each other back. Managed effectively, novel concepts, technology, and methods spur one another forward, enabling practitioners to be innovative and forward-looking rather than

[24] Law coined the term to describe one comfortable not only in his technical field but also in the wider world and able to understand and deal with the social, cultural, political, and economic ramifications of technology and its development. Hughes's depiction of Schriever certainly fits this bill. John Law, "Technology and Heterogeneous Engineering: The Case of Portuguese Expansion," in *The Social Construction of Technological Systems*, 107.

repeating the mistake of looking backwards and planning again for the prior war.

The First World War saw the advent of fixed-wing aircraft above the battlefield. The war ended before their full array of capabilities were known, but the period after World War I gave American airpower pioneers the opportunity to explore aviation's military possibilities. This was a case of seeking advantage for an anticipated future as described above. The ideas were new, presumably useful in the context of a total war, and generally accepted in the community of practicing airmen. Therefore, they meet our definition of innovation. The available hardware, however, did not fit with their revolutionary ideas, and new technology was required. Technology drove strategy and, in turn, strategy drove technology. Problems occurred when one had primacy over the other, but the real lesson to take from the interwar period of 1919-1938 is that strategy and technology are mutually reinforcing and, kept in proper balance, drive each other forward.

Technological revolution opened new possibilities for thinking about military strategy. The airplane's complete freedom of action in all directions made it possible to go far behind the fortified lines of adversaries without first destroying their ground forces.[25] General Billy Mitchell argued that this made new strategic ideas not only possible, but also necessary.[26] The horrors of grinding attritional land warfare seen in World War I drove a desire to bypass the fielded army in hope that airpower could achieve a military purpose cheaply and quickly.[27] In this way, Mitchell cast himself as the engineer for this new system of thought and framed his argument as solving the problem of trench warfare. If

[25] Colin Gray, *Air Power for Strategic Effect*, (Maxwell AFB, AL: Air University Press, 2012), 104-105.
[26] William "Billy" Mitchell, *Winged Defense: The Development and Possibilities of Modern Air Power – Economic and Military*. 1925. Reprint, (Tuscaloosa, AL: University of Alabama Press, 2009), 6.
[27] Robert A. Pape, *Bombing to Win: Air Power and Coercion in War,* (Ithaca, NY: Cornell University Press, 1996), 65.

armies were no longer the primary focus, capitalizing on this new capability of deep strike required new thinking about what to target.

Borrowing from European theorists, American airpower advocates proposed that the real objective in warfare was not defeating the enemy's military, but rather civilian morale and the national will to fight. While Europeans espoused attacking civilian population centers directly, the Americans believed the way to erode the moral will was to destroy the adversary's economy, particularly the industrial capacity that enabled war making.[28] Mitchell argued in 1919 that airpower could reach and destroy a nation's vital centers of production including factories, raw materials, transportation facilities, and foodstuffs. Since these were all necessary both for warfighting and a domestic economy, destroying them held the most promise for ending a conflict quickly and decisively.[29]

In the 1930s, the instructors at the U.S. Army's Air Corps Tactical School (ACTS) refined these ideas into the theory of the industrial web. Arguing that destroying the entire industrial base was not necessary, they held that the complex interactions in an industrial society made it susceptible to collapse with only a few carefully selected nodes destroyed.[30] Though the social groups involved (i.e., aviators and economists) were certainly limited in scope, the social constructivist theory is evident in the industrial web theory's development. The question was how best to strike these targets. The answer was high altitude daylight precision bombing (HADPB); however, the strategy's advocates recognized they lacked the necessary hardware.

New ways of strategic thinking required new technology. ACTS emphasized bomber procurement at the expense of observation, attack, and pursuit platforms, but the airframes in the early interwar period did

---

[28] Pape, *Bombing to Win*, 64.
[29] Mark Clodfelter, *Beneficial Bombing: The Progressive Foundations of American Air Power, 1917-1945.* (Lincoln, NE: University of Nebraska Press, 2010), 41.
[30] Pape, *Bombing to Win*, 62-63.

not match the strategy of strategic bombardment. The standard scout bomber in the 1920s was the MB-2, a biplane with a ceiling of only 7,700 feet, a bomb load of just over 1,000 pounds, and top speed of 98 miles per hour.[31] The B-9 and B-10 brought incremental improvements in the early 1930s. Though considerably faster with an improved ceiling, these two-engine monoplanes still could not carry a heavy load for long distances.[32] At decade's end the primary bomber, the B-18 Bolo, was best suited for short-range interdiction and battlefield support.[33] Not until 1937 did the Air Corps receive its first B-17 bombers capable of carrying loads of 2,500 pounds for over 2,000 miles with a ceiling over 20,000 feet.[34] The airframe, however, was only part of the technology needed to make HADPB viable.

The Norden bombsight was a gyro-stabilized, motor-driven telescope that allowed a bombardier to calculate a precise drop time adjusted for wind, altitude, and ballistics information of the bomb. At high altitudes in ideal training conditions, the accuracy was far from perfect, but coupled with the B-17, the device promised to increase dramatically the chances that HADPB could indeed strike critical nodes of the industrial web.[35] As the prospect of war in Europe loomed in the late 1930s, it became clear that the Air Corps required thousands of B-17s equipped with the Norden bombsight to be effective.[36] The Air War Plans Division campaign plan to defeat Germany (AWPD-1) prescribed strategic bombing and called for massive procurement of Norden-equipped bombers. The document was the culmination of the mutually

[31] Tami Davis Biddle, *Rhetoric and Reality: The Evolution of British and American Ideas about Strategic Bombing, 1914-1945*, (Princeton, NJ: Princeton University Press, 2002), 146.
[32] Clodfelter, *Beneficial Bombing*, 70.
[33] Clodfelter, *Beneficial Bombing*, 50.
[34] Biddle, *Rhetoric and Reality*, 146.
[35] Clodfelter, *Beneficial Bombing*, 71-72.
[36] Gray, *Air Power for Strategic Effect*, 106.

reinforcing interaction of strategy and technology between 1919 and 1938.

The interwar period's lesson for today's airpower practitioners and strategists is that the cycle of new ideas and new technology requires balance. Allowing technology precedence over sound strategic thinking risks procuring the wrong tool for the task. Holding too fast to a particular strategy or doctrine can hamper technological innovation and perpetuate shortcomings. Planners must manage these risks to foster the required balance. The great danger in placing the drive for better technology ahead of sound strategy is building a modern air power that "focuses on the lethality of its weaponry rather than on that weapon's effectiveness as a political instrument."[37] The U.S. Air Force has a reputation for treating airpower and the platforms that deliver it as an end in themselves rather than a means to accomplish objectives. This is evident in the tendency to overpromise the degree of decisiveness airpower brings to the fight – a tendency that traces back to the interwar period. This is not to say that new technologies should be ignored when it comes to strategic thinking. These lessons are important to apply as the Air Force moves into the future.

In an effort to expand or maintain asymmetric advantages over America's adversaries, the USAF's *Strategic Master Plan* (SMP) of 2015 calls for a new approach to technological innovation. The specific strategic vector in the document focuses on "game-changing technologies"[38] In a resource-constrained environment, the traditional focus on large procurement programs based on an assumed future threat is inappropriate. The SMP instead seeks to establish an environment for creative approaches through small investments in experimentation to

---

[37] Mark Clodfelter, *Limits of Air Power: The American Bombing of North Vietnam*, (Lincoln, NE: University of Nebraska Press, 2006), 203.
[38] Department of the Air Force, *USAF Strategic Master Plan,* (Washington, DC: Department of the Air Force, 21 May 2015), 59.

build a technology base. This approach of building a technology base for an uncertain future makes sense. Maintaining and expanding asymmetric advantage over America's adversaries is sound policy. It is difficult to argue against this point if our mission is to deter and, when necessary, to fight and win our nation's wars. What, though, is the source of our asymmetric advantage?

The air war over Vietnam demonstrated the fleeting nature of military advantage. When both sides are capable of rapid innovation, advantage cycles back and forth between them. In *Clashes: Air Combat over Vietnam 1965-1972*, Marshall Michel provides several examples of innovation by both the North Vietnamese and the Americans. These innovations involved both machines and human factors such as tactics and training. The introduction of the SA-2 and the MiG-21 by the communists drove the Americans to develop and employ different tactics as well as electronic counter measures and improved munitions.[39] Wartime innovation must be quick and is normally reactive. It often involves trial and error with incremental improvement (what Rosen calls reform versus true innovation) rather than more effective developmental testing.[40] New technology enables new tactics and vice versa. An important lesson informing the SMP is that machines and human factors must be coupled and considered together.

To be truly "game-changing," technology must be understood holistically, not simply as artifacts. The ideas from both the social constructivist school of technological innovation and the large systems theory inform the approach to future innovation advocated in the SMP. The strategic vector appears to be a departure from the singular focus on artifacts that marked past technological development in the Air Force.

---

[39] Marshall L. Michel, *Clashes: Air Combat Over Vietnam, 1965-1972*, (Annapolis, MD: Naval Institute Press, 1997), 236.
[40] Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military*, (Ithaca, NY: Cornell University Press, 1991), 30.

Indeed, the document clearly states that the purpose is not identifying specific technologies, but outlining a strategic approach to enable game-changing capabilities. It goes on to say that, "[g]ame-changers do not result solely from technology, but rather from the specific ways in which a technology is applied in an operational capability…"[41] This focus on capabilities as opposed to platforms reflects a recognition of the role of human factors in socially constructed technological innovation. Further evidence lies in the list of key elements considered necessary to cultivate game-changing capabilities – innovative people, ideas and concepts, experimentation, and an active, engaged leadership.[42] These capabilities will manifest as new tactics, new doctrine, new organizations, and new weapons and ways to use them.

The descriptions of these key elements reflect a social-constructivist approach to developing a technological base. The SMP strategic vector describes innovation as the result of insightful, collaborative interactions between creative people in open, risk-accepting environments. This reflects the give and take between relevant social groups identifying and addressing problems rather than simply completing a given task. This crowdsourcing approach should enable new ways of thinking about airpower. As Posen argues, new technologies are normally assimilated into old doctrine rather than stimulate change to a new one.[43] Such institutional inertia is the antithesis of true innovation. The document stresses that current doctrine or requirements levied by current solutions must not constrain innovative ideas and concepts. This change to our normal operating practice is critical for the Air Force to be truly innovative in building a technological

[41] Department of the Air Force, *Strategic Master Plan,* 59.
[42] Department of the Air Force, *Strategic Master Plan,* 59.
[43] Barry R. Posen, *The Sources of Military Doctrine: France, Britain, and Germany Between the Wars*, (Ithaca, NY: Cornell University Press, 1984), 55.

base for an uncertain and increasingly complex future security environment.

The SMP approach to making many small investments and a "campaign of experiments" is reminiscent of early efforts in the Defense Advanced Research Projects Agency's (DARPA) strategic computing initiative. Ostensibly, the project focused on a single problem – artificial intelligence – through cooperative development of subsystems. According to Alex Roland and Philip Shiman, rather than set out a specific plan or strategy for a particular project, the strategic computing project boasted a grand strategy to advance an entire research front. In practice, however, the project was not a coordinated effort towards one solution, but rather a pot of money used to develop a technology base.[44] The strategic-computing effort ultimately failed in its charter to develop artificial intelligence, but the spin-off technologies it spawned have proven useful in many ways. This is somewhat of a cautionary tale for the SMP approach to technology.

Because the SMP is purposefully setting out to develop a technology base, the strategic computing model of separate experiments makes sense. However, if a particular concept proves worthy of a major investment and large development program, the failures of the strategic-computing program to connect components teaches a different lesson. In the event that a large development program emerges, the Air Force should adopt a large technical systems model where a system-builder can bridge the social groups, overcome institutional inertia, and carry the project to fruition.

The SMP's call for continuing the pursuit of game-changing technologies by establishing a base for future innovation in order to expand or maintain our asymmetric advantage over America's

---

[44] Alex Roland and Philip Shiman, *Strategic Computing: DARPA and the Quest for Machine Intelligence, 1983-1993*, (Cambridge, MA: MIT Press, 2002), 331.

adversaries is sensible. The world is increasingly complex and more and more uncertain. In a severely resource-constrained environment, it is foolish to continue to pursue large technology projects when we cannot confidently predict whether a platform will reach obsolescence before or soon after deployment. No static certainty is to be found in politics or political science, hence the importance of cultivating an affirmative, inventive, flexible mind.[45] The social constructivist approach to developing a technology base from which to draw is sound, so long as any large projects that emerge from it can benefit from a more traditional large technical systems approach.

Summary

This chapter explored innovation – what it is, how it works, and how it might look in the profession of arms. Innovation essentially is putting creativity into practice. Indeed, defining innovation as the development of novel concepts, technologies, or methods to solve problems or deliver a decisive advantage in a particular social context exposes the intimacy of its relationship with creativity. Where creativity is the generation of ideas, innovation takes place only when a community of practice adopts those ideas for use. As such, innovation is socially constructed. It may be evolutionary and incremental as the social constructivist theorists demonstrate with the development of the bicycle. On the other hand, it may be through the concerted purposeful efforts of a heterogeneous engineer as the large technical systems theorists portray in Bernard Schriever's leadership in ICBM development. In either case, managed effectively, novel concepts, technology, and methods spur one another forward, enabling practitioners of the profession of arms to be innovative and forward-looking rather than repeating the mistake of

---

[45] Harold Lasswell, "Cultivation of Creativity," *Creativity: Being Usefully Innovative in Solving Diverse Problems*, ed. Stuart Nagel, (Huntington, NY: Nova Science Publishers, Inc., 2000), 99.

looking backwards and planning again for the prior war. The next chapter turns to another of the CSAF's priorities, critical thinking.

Chapter 4

CRITICAL THINKING AND THE PROFESSION OF ARMS

An education isn't how much you have committed to memory, or even how much you know. It's being able to differentiate between what you do know and what you don't.

- Anatole France

No way of thinking or doing, however ancient, can be trusted without proof.

- Henry David Thoreau

The CSAF identifies critical thinking, along with creativity and innovation, as critical combat capabilities for the Air Force. This relationship of critical thinking to creativity and innovation is mutually supporting. Thinking critically enables better decision-making and protects leaders and strategists from catastrophic miscalculation. It is important, then, to understand just what critical thinking is and why it matters. This chapter explores critical thinking – what it is, how it works, and what it means to the profession of arms.

Conceptualizing Critical Thinking

As with creativity and innovation, people in countless disciplines parrot the term "critical thinking" without much thought to what it really is. Operationalizing an abstract construct like critical thinking requires a working definition. This allows observers to reliably identify the construct and differentiate thinking that is "critical" from that which is not. Absent a working definition, we cannot know whether critical thinking occurs, much less, whether it is successful. Despite a robust literature on the subject and a long history of its practice, researchers in the discipline warn that the entire field of critical thinking scholarship

suffers from a definitional dilemma.[1] Some scholars define critical thinking as the development of logical reasoning abilities. Others describe it as the application of reflective judgment.[2] Robert Ennis defines critical thinking as "reasonable reflexive thinking focused on deciding what to believe or do."[3] These all are reasonable for guiding academic study, but do not offer much help for a practical definition. Critical thinking is more than an abstract academic activity. Rather, it is something all humans do, though its frequency and quality vary from person to person. Like creativity and innovation, one should conceptualize critical thinking as an action rather than a noun.

Critical thinking is a cognitive process, or rather a set of cognitive processes. This is admittedly tautological, but it is an important point that ties critical thinking to creativity and innovation. A creative mind, unbound by dogma, sees possibilities. A critical mind assesses those possibilities and decides upon a course of action, often leading to innovation. At its essence, critical thinking is about using processes to evaluate and select information in order to improve one's judgment and make better decisions.[4] This suggests a purpose, but does not identify specific processes. Being a critical thinker involves more than logical reasoning and scrutinizing arguments for unsupported assertions. These activities are oriented outside oneself. Thinking critically is a process of metacognition, or being conscious of one's own thinking

[1] Diane F. Halpern, "The 'How' and 'Why' of Critical Thinking Assessment" in in *Critical Thinking and Reasoning: Current Research, Theory, and Practice.* ed. Daniel Fasko, Jr. (Cresskill, NJ: Hampton Press, Inc., 2003), 357.
[2] Stephen D. Brookfield, *Developing Critical Thinkers: Challenging Adults to Explore Alternative Ways of Thinking and Acting*, (San Francisco, CA: Jossey-Bass Publishers, 1987), 11.
[3] Robert H. Ennis, "Critical Thinking Assessment," in *Critical Thinking and Reasoning: Current Research, Theory, and Practice*. ed. Daniel Fasko, Jr. (Cresskill, NJ: Hampton Press, Inc., 2003), 295.
[4] Charles D. Allen and Stephen J. Gerras, "Developing Creative and Critical Thinkers," *Military Review* 89, no. 6 (Fort Leavenworth, KS: US Army Combined Arms Center, Nov-Dec 2009), 78.

during the act of thinking and problem solving.[5] Critical thinking involves questioning the assumptions underlying customary, habitual ways of thinking and acting; and more importantly, the readiness to think and act differently based on this critical questioning.[6]

In the term critical thinking, the word "critical" does not imply "finding fault," but it does involve evaluation or judgment, ideally with the goal of providing useful and accurate feedback that serves to improve the thinking process.[7] Sometimes individuals portray critical thinkers as cynical people who simply condemn the ideas of others without contributing anything positive themselves. Holders of this view see being critical as belittling and indicative of false assumptions of superiority. In fact, the opposite is true. Critical thinking is a productive and positive activity. Thinking critically makes us aware of different values, behaviors, and perspectives. We learn that others often have the same sense of certainty that we do, but about ideas that are completely contrary to our own. This engenders a measure of humility in our commitments to our own points of view.[8] Such humility allows us to identify our assumptions, assess them, and if necessary, alter them. This explains the benefit of critical thinking, but still does not say what it is.

The concept of critical thinking traces its roots to the teaching technique of Socrates around 2,400 years ago. The "Socratic Method" involves asking probing questions that lead students beyond speculation and belief to true understanding and knowledge.[9] Recall the discussion

---

[5] Arthur L. Costa, "Communities for Developing Minds," in *Critical Thinking and Reasoning*, ed. Fasko, 61.
[6] Stephen D. Brookfield, *Developing Critical Thinkers: Challenging Adults to Explore Alternative Ways of Thinking and Acting*, (San Francisco, CA: Jossey-Bass Publishers, 1987), 1.
[7] Halpern, "The 'How' and 'Why' of Critical Thinking Assessment," 356.
[8] Brookfield, *Developing Critical Thinkers*," 5.
[9] Daniel Fasko, Jr., "Critical Thinking: Origins, Historical Development, Future Directions," in *Critical Thinking and Reasoning: Current Research, Theory, and Practice.* ed. Daniel Fasko, Jr. (Cresskill, NJ: Hampton Press, Inc., 2003), 3.

of Bloom's Taxonomy of Learning from Chapter 2. Probing questions move learners through the lower taxonomic levels (remember, understand, and apply) to the higher taxonomic levels (analyze, evaluate, and create).[10] By developing these skills, thinkers are able to draw connections among ideas, compare and critique possible solutions, and conjecture possible second- and third-order effects.[11] Socratic questioning is not strictly synonymous with critical thinking. However, it does move us closer to a functional definition. Stephen Brookfield noted that critical thinking is a process involving two observable activities: identifying and challenging assumptions; and exploring and imagining alternatives.[12] By coupling this "what" with the "why" from above, our working definition of critical thinking becomes the process of identifying and challenging assumptions and exploring and imagining alternatives in order to improve one's judgment and make better decisions. So, how do we put these activities into practice?

How Critical Thinking Works

Exploring how critical thinking works begins with understanding some foundational premises. Vincent Ryan Ruggiero identified several critical principles and axioms underlying critical thinking. These include:

- An idea cannot be both true and false at the same time in the same way;
- for every problem one solution is better than all others;
- for every issue one view is wiser and more insightful than all competing views;
- critical thinking aims at finding not *an* answer, but the best possible answer;
- one can have convictions and still think critically;

---

[10] Patricia Armstrong, "Bloom's Taxonomy" Vanderbilt University Center for Teaching, accessed 27 March 2016, https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/#2001.
[11] David A. Sousa and Tom Pilecki, *From STEM to STEAM: Using Brain-Compatible Strategies to Integrate the Arts* (Thousand Oaks, CA: Corwin, 2013), 41-42.
[12] Brookfield, *Developing Critical Thinkers*, 14-15.

- and the essence of critical thinking is evaluation and judgment.[13]

Since we are examining critical thinking, we naturally do not take Ruggiero's principles at face value. Rather, we examine them for validity. The first is basic rational logic. Any thinking about an idea that could be both right and wrong at the same time in the same way would yield nothing in terms of improved judgment and decision-making. Thus, thinking critically about such an idea is necessarily impossible. The next three axioms are arguably subtle restatements of one another. Thinking critically does not guarantee arriving at the best solution or wisest view, but seeking the best possible answer is an appropriate goal. We examine the critique that critical thinking precludes true conviction more thoroughly below, but the last principle alludes to an answer. Judgment, preferably informed by evaluation, is indeed a precursor to conviction. Armed with these validated principles, we now can explore how to put critical thinking into practice.

Critical thinking is not a discretely separate phenomenon. Rather, it is a cluster of activities or operations. These operations occur, to greater or lesser extents, at certain times. Brookfield in a later work refined the two activities of our functional definition (identifying and challenging assumptions; and exploring and imagining alternatives) by describing them as four operations. These operations are assumption analysis, contextual thinking, imaginative speculation, and reflective skepticism.[14] For the sake of examination, they are treated as distinct operations, but in practice, they are interactive and intertwined.

The process of assumption analysis usually begins when one encounters a discrepancy between assumptions and perspectives that

---

[13] Vincent Ryan Ruggiero, "Neglected Issues in the Field of Critical Thinking" in Fasko, *Critical Thinking and Reasoning*, 372-374.

[14] Stephen D. Brookfield, "Critical Thinking in Adulthood" in Fasko, *Critical Thinking and Reasoning,* 159.

seem to explain the world satisfactorily and what one observes in real life. Prior to such an event, thinking is more or less automatic because it is psychologically comfortable. The world is functioning as expected. Confronted with the cognitive dissonance between expectations and reality, however, a human experiences psychological discomfort. This discomfort motivates the person to try to reduce dissonance and achieve consonance.[15] The risk is that the person simply will avoid the dissonance rather than actually resolve it, and thereby remain mired in faulty assumptions. As a process, critical thinking involves recognizing and assessing the assumptions that undergird our thoughts and actions.[16]

People have cognitive limitations. When they come upon novel situations, human beings relate what they observe to some pattern that is already familiar – a schema – which allows them to recognize similarities and to discern differences.[17] Related to the idea of schema is the concept of a paradigm. Paradigms derive from experience to form accepted conceptual frameworks that not only predict and explain observations, but also actually bound the possible ways of thinking about a given problem.[18] This bounding is necessary for efficiency but often prevents thorough analysis of observed data, thus driving narrow interpretations that will accept the expected but discount the unexpected, a phenomenon Robert Jervis describes as cognitive consistency.[19] This tendency to avoid cognitive dissonance often causes people to discount alternative explanations or predictions. Their initial belief about a given problem tends to persevere even in light of evidence

[15] Robert Jervis, *Perception and Misconception in International Politics*, (Princeton, NJ: Princeton University Press, 1976), 382.
[16] Brookfield, "Critical Thinking in Adulthood," 144.
[17] Yuen Foong Khong, *Analogies at War: Korea, Munich, Dien Bien Phu, and the Vietnam Decisions of 1965*, (Princeton, NJ: Princeton University Press, 1992), 25-27.
[18] Thomas S. Kuhn, *The Structure of Scientific Revolutions*, 4th ed. (Chicago, IL: University of Chicago Press, 2012), 25.
[19] Jervis, 117.

to the contrary.[20] Identifying and analyzing assumptions is critical to breaking free of the bonds of overly paradigmatic thinking.

The first step toward breaking free of overly paradigmatic thinking is to uncover hegemonic assumptions. Brookfield uses this term to describe those assumptions embraced because people think they are in their own best interest.[21] Perversely, these assumptions often actually work against the individual or organization in the long term. In this sense hegemony is the process whereby the majority of people accept ideas, structures, and actions as wholly natural, pre-ordained and working for their own good. Over time, these take deep root, becoming simply part of the culture one lives and breathes. Personal experience cultivates these ideas and practices. They become just part of everyday life – the stock opinions, conventional wisdom, or commonsense ways of seeing and ordering the world that people take for granted.[22] Once aware of these assumptions, one can account for them as she moves through the other operations of critical thinking, ideally before any cognitive dissonance occurs.

Identifying and challenging assumptions help foster contextual awareness. Understanding the importance of context is crucial for thinking critically. Non-contextual thinkers believe that value systems and behavioral codes are personally generated or simply self-evident. This is a recipe for overly paradigmatic – even dogmatic – thinking. Personal experiences certainly influence beliefs and values, but the context in which they find themselves conditions what individuals consider moral, just, or equitable. Contextual awareness stems from the recognition that the assumptions undergirding our beliefs and actions are culturally and historically specific.[23] Contextual thinkers recognize

[20] Khong, *Analogies at War*, 39.
[21] Brookfield, "Critical Thinking in Adulthood," 144.
[22] Brookfield, "Critical Thinking in Adulthood," 144-145.
[23] Brookfield, "*Developing Critical Thinkers*," 16.

that their own value systems and behavioral codes are socially constructed and transmitted. Thus, contextual thinkers understand that others' value systems and behavioral codes likewise develop from their socially constructed assumptions. The realization that every belief held dear, every behavior deemed normal, and every social structure seen as natural and unalterable can be and is regarded by other people as bizarre, inexplicable, and wholly irrational prevents mirror imaging when exploring options and making decisions vis-à-vis other actors.[24]

Another vital aspect of critical thinking is exploring alternatives. Critical thinkers must acknowledge assumptions and assess them contextually against empirical data. They also must assess them against other possibilities through imaginative speculation.[25] This demonstrates the clearest intersection of creative and critical thinking. Recall that creativity is the capacity to produce novel, useful things or ideas that meet contextual constraints of a given domain. Proposing novel and useful alternatives is the essence of Brookfield's imaginative speculation. Realizing that alternatives exist to our present ways of thinking necessarily reinforces the operation of identifying and challenging assumptions. Additionally, if imaginative speculation uncovers a better or more appropriate alternative, the critical thinker can adopt that alternative as a new paradigm subject to its own critical analysis. Unfortunately, education programs that seek to teach critical thinking as a skill often omit this crucial operation.

Ruggiero lamented that most students of critical thinking learn how to evaluate other people's ideas but not how to produce ideas of

---

24 Brookfield, *Developing Critical Thinkers*, 18.

25 Thomas Kuhn makes this point regarding scientific paradigms when he points out that the decision to reject one paradigm is simultaneously the decision to accept another. The judgment leading to that decision involves the comparison of both paradigms with nature (i.e., what is observed) and with each other. Kuhn, *The Structure of Scientific Revolutions*, 78.

their own.[26] This reflects a difference between productive and reproductive thought. Productive thought (i.e., creative thinking) is more complex and dynamic, whereas reproductive thinking (e.g., echoing or reiterating) lacks insight.[27] Ruggiero also noted that these students gain considerable practice analyzing arguments about controversial issues but seldom if ever face true problem-solving challenges. Reciprocally, creative thinking students learn a great deal about idea production but little about idea evaluation.[28] Effective thinking for problem solving, issue analysis, and decision-making must entail both the production and evaluation of ideas.

When others claim the universal truth or validity of an idea or practice, people rightly become suspicious. A sense of skepticism keeps us from taking for granted such statements or justifications based on some ascribed authority as a source of truth. We reject justifications like "That's just the way things are" or "Because it's how we've always done it." This is not unthinking pure skepticism that dismisses any and all claims to truth on principle. Rather, it is a cautious consideration of grandiose claims regarding "ultimate" truth or "final" solutions.[29] Evaluating the arguments of others is straightforward and focuses externally. Evaluating our own ideas is not as simple. Focused internally, reflective thinking is more difficult because it carries more psychological risk.

Reflective thinking does not come naturally. Humans are prone to premature closure. Our discomfort with uncertainty and ambiguity drives us to reach conclusions or accept explanations before carefully considering all the facts and the logical solutions flowing from those

---

[26] Vincent Ryan Ruggiero, "Neglected Issues in the Field of Critical Thinking" in Fasko, *Critical Thinking and Reasoning*, 375.
[27] Fasko, Jr., "Critical Thinking: Origins, Historical Development, Future Directions," 4-5.
[28] Vincent Ryan Ruggiero, "Neglected Issues in the Field of Critical Thinking" in Fasko, *Critical Thinking and Reasoning*, 375.
[29] Brookfield, *Developing Critical Thinkers*, 20-21.

facts.[30] This is arguably an adaptive behavior in that it helps us avoid cognitive dissonance. In truth, however, this drive for cognitive consistency is maladaptive because it causes individuals to disregard incongruent information, which prevents effective analysis of assumptions and contextual thinking. To avoid this trap, an individual must develop reflective skepticism.

Reflective skepticism is the active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends. It includes conscious and voluntary effort to establish belief upon a firm basis of evidence and rationality.[31] It grows from considering and imagining alternatives and aids in assumption analysis. We should not reserve reflective thinking for addressing problems and issues. Rather, it should operate more or less continually, sorting through experience and observation. Reflective thinking seeks to identify new problems and issues while also finding data that will be useful in dealing with those already identified.[32] The iterative nature invites criticism that critical thinkers avoid commitment to beliefs or refuse building allegiance to a cause. This is neither fair nor accurate. Critical assessment means such commitment comes through questioning, analysis, and reflection. Critical thinkers establish validity by examining the ideas, structures, and causes for congruence with perceived reality.

The foregoing discussion demonstrates how Brookfield's four operations – assumption analysis, contextual thinking, imaginative speculation, and reflective skepticism – interact and enable one another. Additionally, the same sort of mutually supporting relationship exists between the operations and Ruggiero's axioms listed at the beginning of

[30] Richard Restak, *Mozart's Brain and the Fighter Pilot: Unleashing Your Brain's Potential* (New York, NY: Harmony Books, 2001), 156-157.
[31] Fasko, "Critical Thinking: Origins," 7.
[32] Ruggiero, "Neglected Issues in Critical Thinking," 376.

the section. These constructs are useful for understanding how critical thinking works. However, putting critical thinking into real practice requires a more concrete list of skills and activities. Robert Ennis provides such a list. He rightly contends that reasonable reflective thinking requires some or most of the following in combination:

1. Identify conclusions, reasons, and assumptions.
2. Judge the quality of an argument, including the acceptability of its reasons, assumptions, and evidence.
3. Develop and defend a position on the issue.
4. Ask appropriate clarifying questions.
5. Formulate hypotheses, plan experiments, and judge experimental designs.
6. Define terms in a way appropriate to the context.
7. Be open-minded and mindful of alternatives.
8. Try to be well informed.
9. When warranted, draw conclusions, but do so with caution.
10. Integrate the situationally relevant items in this list in deciding what to believe or do.[33]

As with the activities and operations discussed previously, these items have aspects that focus externally as well as internally. Both types of assessment are critical to sound judgment and decision-making. This menu of skills and behaviors encompasses the components of our functional definition and serves essentially as a checklist for critical thinking. This seems appropriate as the discussion moves to critical thinking's role in the profession of arms.

Applying Critical Thinking in the Profession of Arms

The capacity to generate and evaluate possibilities from varied perspectives is particularly useful for leaders and strategists faced with poorly defined problems that have multifaceted solutions – an apt description of the increasingly complex operating environment. Susan Craig, writing when she was a red-team analyst at the US Pacific

[33] Ennis, "Critical Thinking Assessment," 295.

Command Joint Intelligence Operations Center, notes the importance of not using a single construct to define the operational environment. Echoing Khong's *Analogies at War*, she warns that strictly adhering to a single model or applying inappropriate metaphors and analogies enables mental shortcuts that often lead to failure.[34] In other words, Craig stresses understanding the context of the operational environment by identifying and challenging assumptions and exploring and imagining alternatives in order to improve judgment and decision-making. This is sage advice both for the individual and for the larger bureaucracy, since cognitive errors occur both at the individual and organizational level and across the tactical, operational, and strategic levels of war.

The processes by which strategists choose information they deem pertinent, and choose to ignore that which does not fit a paradigm, is similar at any level. In fact, organizational structures often reinforce the tendency to seek cognitive consistency. Shared paradigms allow organizations to function as a system. However, they also can produce groupthink that prevents alternate perspectives and explanations taking shape in deliberations. Acknowledging these tendencies is the first step toward developing organizational processes that can mitigate these limits of human cognition. Establishing robust systems of assessment that ask the right questions is vital. This requires considering different perspectives, particularly an opponent's point of view. Changing basic assumptions, however, is extremely difficult because it requires reexamining the very thing that allows an organization to function. This challenge can be so cognitively destabilizing that it is more likely that members of that culture will find behavior or belief based on any other premise as inconceivable.[35] A risk of such blind faith is an inability – or

[34] Susan Craig, "Reflections of a Red Team Leader," *Military Review* 87, no. 2 (Fort Leavenworth, KS: US Army Combined Arms Center, March-April 2007), 58.
[35] Edgar H.Schein, *Organizational Culture and Leadership,* 4th ed. (San Francisco, CA: Jossey-Bass, 2010), 28.

unwillingness – to learn from contrary evidence. Another look at the work of the Air Corps Tactical School (ACTS) provides an example at the level of doctrine.

Overarching enthusiasm for strategic bombing trumped any concern that such an approach was difficult even in the best conditions. The ability to attack selected targets with precision from high altitudes assumed that airplanes could reach those targets without sustaining prohibitive losses in the process. Envisioning longer-range missions, planners counted on self-defending bombers reaching distant targets unescorted.[36] The 1930 text on bombardment acknowledged that pursuit aircraft proved enough of a problem for daytime bombing in World War I that all belligerents moved to night operations. Even so, ACTS instructors adhered to doctrinal belief in strategic bombing and argued that high altitudes, speed, and large formations would protect bombers from defending pursuit aircraft. Air engagements in the Spanish Civil War, however, made clear that bombers' defensive armament did not deter attack by fighters; hence, escorts were essential for effective bombardment. Despite clear knowledge of this, Air Corps leaders did not challenge their doctrinal assumptions. Not until 1943, only after disastrous losses over Germany, did escorts become a priority.[37] Tactical-level successes sometimes overcome doctrinal failure at the operational level. Curtis LeMay's critical thinking did just that in the skies over Europe.

In command of the 305th Bomb Group, LeMay questioned the tactic of taking evasive action to avoid enemy flak during a bomb run. The conventional wisdom held that flying straight and level for more than ten seconds sealed a B-17's fate. Thinking contextually, LeMay realized

---

[36] Tami Davis Biddle, *Rhetoric and Reality: The Evolution of British and American Ideas about Strategic Bombing, 1914-1945*, (Princeton, NJ: Princeton University Press, 2002), 164-165.
[37] Biddle, *Rhetoric and Reality*, 173-174.

that the resultant misses meant returning to the target again and again, exposing more men and more airplanes to danger. He also recognized that flak patterns were essentially random. The fact that anti-aircraft artillery did not actually aim at a particular airplane meant that evasive action gave no advantage to the bomber.[38] Having successfully challenged the organizational assumptions through straightforward logic, LeMay turned to examining alternatives.

Using an artillery manual, LeMay calculated that hitting a target the size of the Flying Fortress, even flying straight and level, would take 272 rounds of ammunition. Liking those odds, LeMay briefed the 305th that they would be making the bomb run without the usual evasive maneuvers. To show his confidence in the decision, LeMay led the unit's first mission himself. Upon reaching the target area at St. Nazaire, the 305th flew the bomb run straight and level for 420 seconds. The group lost two bombers to enemy pursuit aircraft, but none to flak. Moreover, aerial photography showed that the 305th put twice the number of bombs on target than the other groups on the mission. From then on, LeMay's bombing tactics became standard operating procedure across the command.[39] LeMay successfully challenged assumptions and explored alternatives that improved his and the organization's judgment and decision-making. Operations that are more contemporary provide positive and negative examples as well.

The early major combat operations of Operation Iraqi Freedom provide an example of successful departure from rigid doctrinal thinking. The beginning of the Iraq air campaign in 2003 looked like the beginning of Operation Desert Storm. The US Air Force adhered to its doctrine of long-range strategic bombing in an attempt to decapitate Iraqi regime. This initial strike failed to kill Saddam and his sons at Dora Farms, and

[38] Donald L. Miller, *Masters of the Air: America's Bomber Boys Who Fought the Air War Against Nazi Germany*, (New York, NY: Simon and Schuster, 2006), 105.
[39] Miller, *Masters of the Air*, 105-106.

air forces began parallel strikes on other strategic targets along with Saddam's fielded forces. As the ground invasion proceeded, the success of these tactical-strike missions was obvious. Soldiers stated that as they proceeded to Baghdad everywhere they looked they saw burned-out hulls of Iraqi tanks.[40] This ability to adapt at the operational level led to quick victory over Iraq's regular armed forces. Unfortunately, as the contextual environment changed, the US-led coalition was slow to adapt.

The 2003 invasion of Iraq and subsequent prolonged counterinsurgency demonstrate a failure to think critically at the strategic level. Secretary of Defense Donald Rumsfeld believed that Operation Desert Storm represented the beginning of a revolution in military affairs (RMA). The thinking was that stealth technology and precision-guided munitions coupled with information superiority meant smaller, leaner armed forces could deliver an overwhelming blow.[41] The rapid victory over Taliban forces in Afghanistan convinced the secretary this thinking was right. So taken was Rumsfeld with the idea of an RMA that he ignored the different contextual elements and rejected the advice of his top military advisers regarding the size of the force necessary to conquer Saddam's army and secure the peace in Iraq.[42] His assumption that Iraqis would treat American troops as liberators proved so thoroughly dogmatic that as conditions deteriorated he refused to see it. Rumsfeld went so far as effectively putting a gag order on the word insurgency.[43] The secretary not only failed to think critically, he prevented the organization from doing so as well.

Success in war requires an open and adaptive system for analyzing the context of the current situation and making predictions to progress

[40] Williamson Murray, "Operation Iraqi Freedom, 2003," in *A History of Air Warfare*, ed. John Andreas Olsen, (Washington, DC: Potomac Books, 2010), 287-291.
[41] Keith L. Shimko, *The Iraq Wars and America's Military Revolution*, (Cambridge, UK: Cambridge University Press, 2010), 134.
[42] Shimko, *The Iraq Wars*, 143-144.
[43] Tim Harford, *Adapt: Why Success Always Starts with Failure*, (New York, NY: Picador, 2011), 46-47.

toward the defined objective. When acting within a complex system, precisely predicting results is impossible. One should always challenge constructs that assume understanding such complexity is easy.[44] Opportunities to apply creative thought and critical analysis abound in the current tactical environment. Strategic thinking, though, requires time and resources devoted to its development.[45] Strategic is not simply a level of command, but rather the term indicates a structured approach to thinking about problems and how to solve them. Describing something as strategic emphasizes purposeful behavior, specifically, action that is logically linked to larger goals.[46] Military leaders need to assess the situation continuously, develop innovative solutions to problems, and remain mentally agile to capitalize on opportunities.[47] There is no formulaic answer to apply as a one-size-fits-all response to any circumstance. Applying the principles of critical thinking is crucial for success in the profession of arms.

Summary

This chapter explored critical thinking – what it is, how it works, and what it means to the profession of arms. Treating critical thinking as an abstract construct facilitates academic analysis, but its real value comes from putting it in practice. Hence, we defined critical thinking as the process of identifying and challenging assumptions, and exploring and imagining alternatives in order to improve one's judgment and make better decisions. Critical thinking is a cognitive process, the essence of which is evaluation and judgment. It involves questioning assumptions and habitual ways of thinking and acting. More importantly, thinking

---

[44] Craig, "Red Team Leader," 58.
[45] Allen and Gerras, "Developing Creative and Critical Thinkers," 81.
[46] Scott A. Silverstone and Renee Ramsey, "Who Are We Teaching – Future Second Lieutenants or Strategic Leaders?: Education for Strategic Thinking and Action," *Infinity Journal Special Edition "International Relations in Professional Military Education*, Winter 2016, 12.
[47] Silverstone and Ramsey, "Who Are We Teaching?" 12.

critically entails a readiness to think and act differently based on that evaluation and judgment. As an intellectual process, critical thinking is inextricably context-based. Within a given context, thinking critically includes imaginative speculation to explore alternatives. Recognizing other perspectives and possibilities allows for reflective skepticism that helps ensure that belief is established upon a firm basis of evidence and rationality.

The complex security environment demands thinking that is open and adaptive. This is true for individuals and for organizations. It also applies across the levels of war. Examples from the early development of airpower theory and doctrine, tactics in World War II, and operational and strategic decisions in Operation Iraqi Freedom demonstrate why critical thinking is so important to the profession of arms. Critical thinking engenders a sense of humility regarding our convictions that allow us to consider other points of view, identify our assumptions, assess them, and if necessary, alter them. Remaining overcommitted to ideas and plans despite contrary evidence often results in disaster.

This concludes our examination of the habits of mind the CSAF deems critical combat capabilities. The chief calls for creative, innovative, critically thinking airmen to carry the Air Force forward. The final chapter will explore what type of pre-commissioning education best inculcates these habits of mind in the Air Force's officer corps.

Chapter 5

LIBERAL ARTS FOR THE PROFESSION OF ARMS

The point of education must be to create whole people who, through their wholeness, can focus accumulated wisdom of human experience into illuminated patches of splendor.
- Charles Steinmetz, the "Wizard of Schenectady"

Technologies come and go, but the primitive endures…
In this age of technological miracles, our military needs to study mankind.
- Ralph Peters

The CSAF identified creativity, innovation, and critical thinking as critical combat capabilities for an uncertain future characterized by a complex and dynamic operating environment. The previous chapters explored each of these habits of mind, how they relate to one another, and their role in the profession of arms. If the Air Force is to grow Airmen who can effectively lead the institution into the future, it must plant the right seeds and cultivate them with care. This chapter explores the relative merits of different types of undergraduate education for inculcating creativity, innovation, and critical thinking in the future officer corps.

Preparing the Field

Newly commissioned second lieutenants are the future senior strategic leaders of the armed forces, including the Air Force. As noted in Chapter 1, the military services do not hire senior executives laterally as the business sector does. Simply put, we grow our own general officers. To reap the fruit of its labor in developing leaders, the Air Force must pay attention to the seeds it chooses to plant and the fields in which they sow them. This is why pre-commissioning education has strategic significance on two levels. First, it is the foundation for effective action at junior levels of command. Second, it sets the intellectual

conditions necessary for continued professional growth as officers advance to senior ranks and strategic-leadership positions.[48] As such, understanding how military leaders develop their habits of mind is important. Presuming the Air Force promotes its most able officers to flag rank, a look at the educational and occupational backgrounds of the current cadre of Air Force general officers is a start.

A study of the public biographies of 292 general officers captured their commissioning source, undergraduate discipline, advanced academic degree discipline, and career specialty.[49] The survey of biographies conducted for this project was limited to currently serving, active-duty line officers of flag rank. The discrimination was between STEM and non-STEM degrees. Lacking an institutional definition of what constitutes a STEM degree, the analysis applied the AFROTC list of preferred technical degrees for the High School Scholarship Program.[50] Non-STEM degrees were too varied to address individually with any statistical relevancy. Hence, they were categorized as social sciences, humanities, business, and other.[51] Because the preponderance of the 292 general officers in the study were operators, Air Force career specialties were categorized simply as either operators (rated and non-rated) or others. The analysis unearthed some interesting trends and intriguing questions.

---

[48] Scott A. Silverstone, "Introduction: Developing Strategic-Minded Junior Officers," *Infinity Journal Special Edition "International Relations in Professional Military Education,* Winter 2016, 6.

[49] Air Force Personnel Center policy prevents release of any demographic or educational data for general officers. The survey was limited to currently serving active duty line officers of flag rank on 26 February 2016. Reserve mobility advisers, medical officers, judge advocates, and chaplains were not included. Department of the Air Force, "About Us," http://www.af.mil/AboutUs/Biographies.aspx.

[50] Air Force R.O.T.C., "Scholarships: Schools & Majors," https://www.afrotc.com/scholarships/schools.

[51] The category "other" included those that only specified a degree but no discipline (e.g., Bachelor of Science), or if the only advanced degree was a non-technical degree granted through Professional Military Education such as Air Command and Staff College.

The preponderance of operators among current Air Force general officers is not reflective of the officer corps as a whole. Per the 2014 RAND report cited earlier, only a bare majority of non-medical officers are in flying specialties.[52] However, rated officers make up 64 percent of the non-medical general officer cadre. When non-rated operators are also considered, this jumps to 71 percent. This is not in itself problematic, nor at the core of this study. In fact, it makes sense given that air and space operations are the raison d'être of the Air Force. Germane to this study is whether those numbers might skew the comparisons of STEM and non-STEM degreed officers. Given the emphasis on STEM education, one might surmise that the high value placed on operators is a function of their education. However, rates of STEM versus non-STEM undergraduate degrees among current general officer operators mirror the RAND findings on operators as a whole at about half-and-half. Clearly, non-STEM educated officers are just as capable as their STEM-degreed counterparts in developing technical acumen that helps them rise through the ranks. Interestingly, the numbers look quite different regarding advanced academic degrees.

Over twice as many general officers have non-STEM advanced degrees as have STEM advanced degrees. All 292 general officers have at least one advanced degree, seventeen of which were granted through professional military education rather than a civilian university.[53] Of 292 advanced degrees held among current Air Force general officers, 199 (or 68 percent) are in non-STEM fields. This is a significant shift from the 53 percent of STEM undergraduate degrees (fig. 1). Most interestingly, of those general officers who earned a STEM undergraduate

---

[52] Lisa M. Harrington, Lindsay Daugherty, S. Craig Moore, and Tara L. Terry, *Air Force-Wide Needs for Science, Technology, Engineering, and Mathematics (STEM) Degrees*, (Santa Monica, CA: RAND, 2014), 15.

[53] These do not include degrees granted or administered through the Air Force Institute of Technology (AFIT). AFIT degrees were captured as STEM where appropriate or as "Other non-STEM" where the degree did not fit the AFROTC preferred-scholarship criteria for STEM (e.g., Industrial Management).

degree, well over half (54 percent) pursued a non-STEM advanced degree. What might account for this shift, particularly in the military branch that identifies so deeply with being a "technological force?" One possibility is that these officers recognized that technical education did not prepare them for the tasks and challenges they actually encountered as an Air Force officer.

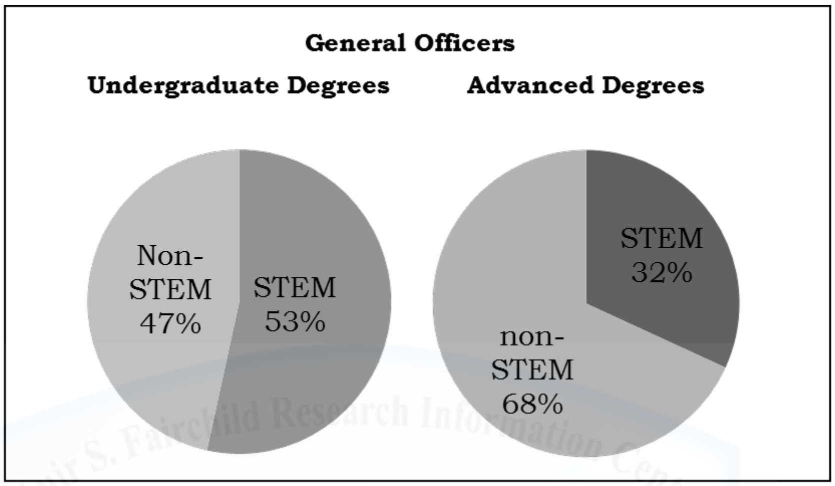

Figure 1. General Officers: Undergraduate and Advanced Degrees
Source: Data derived and compiled from Department of the Air Force. "About Us." http://www.af.mil/AboutUs/Biographies.aspx

Lt Gen Steven Kwast, Commander and President of Air University, is an officer who made the switch from STEM to non-STEM pursuits. Upon graduation from the United States Air Force Academy (USAFA) with a Bachelor of Science degree in astronautical engineering, he pursued a Master of Public Policy degree from the John F. Kennedy School of Government at Harvard University. When asked about the reason so many officers cross from STEM undergraduate to non-STEM graduate studies, Lt Gen Kwast noted that at USAFA, cadets are strongly encouraged to pursue STEM undergraduate degrees. He suggested that this is culturally conditioned by the Air Force identity and its inception being so tied to the emergence of new technology – the airplane. It is possible, then, that these numbers actually tell more about the decision

of an undergraduate field than that of advanced study. Regardless, the general did venture an answer to the question as originally posed.

Lt Gen Kwast noted that his personal motivation for crossing from STEM to non-STEM was a passion for leadership and strategy. He also candidly stated that he was fortunate to be able to focus on graduate school full-time to pursue that passion, but for most officers, balancing the demands of work and family life was probably the more likely motivation than learning particular new skills. After all, graduate studies while working and flying full-time are not easy, particularly in STEM disciplines.[54] Lt Gen Kwast's point is well taken. Still, this implies that what is truly important to the Air Force as an institution is *an* advanced education, rather than a particular *type* of advanced education. This observation about particular fields of study also applies at the undergraduate level as supported by examining the utilization of STEM-degreed accessions.

Of the 156 general officers with a STEM undergraduate degree, only 20 of them entered any of the five Air Force career specialties that currently have a hard, mandatory STEM requirement.[55] As noted previously, the bulk of them became rated or non-rated operators. Looking specifically at the engineering fields, only 19 of 106 engineering graduates entered an engineering Air Force specialty (fig. 2). Their degrees include general engineering, mechanical engineering, electrical engineering, civil engineering, astronautical engineering, chemical engineering, industrial engineering, aeronautical engineering, and human factors engineering. A large majority of engineering graduates – 74 percent – entered operations specialties. As shown earlier, half of

[54] Kwast, Lt Gen Steven L., (Commander and President Air University), in discussion with author, 21 April 2016.

[55] Air Force specialties with a hard mandatory STEM degree requirement include meteorology, civil engineering (including shred outs), developmental engineering (including shred outs), scientists, and physicists. Chapter 1 discusses these in greater detail.

general officer operators hold non-STEM degrees – a clear indication that STEM education is not a requirement for success as an operator. It follows from this that skill sets are more important than academic credentials. The Air University commander was asked about this as well.

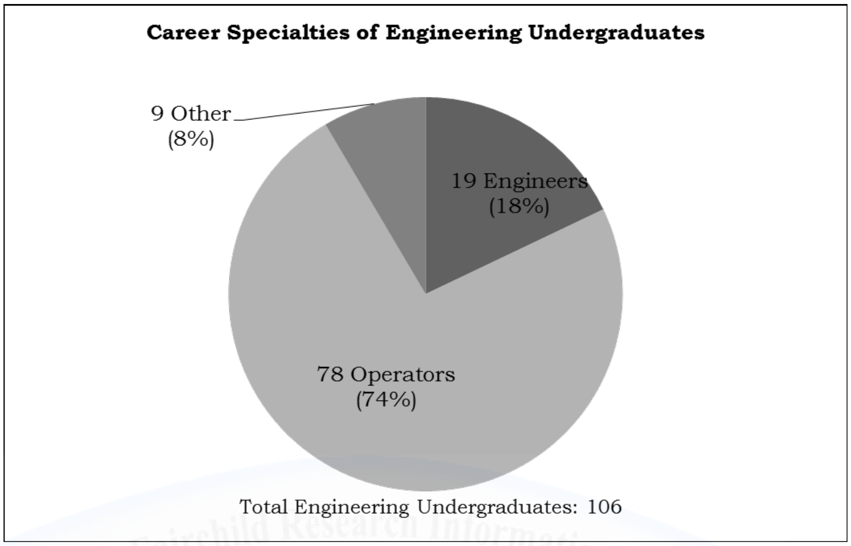

Figure 2. Career Specialties of Engineering Undergraduates
Source: Data derived and compiled from Department of the Air Force. "About Us." http://www.af.mil/AboutUs/Biographies.aspx

Lt Gen Kwast, having commanded at multiple levels, was asked about the skills he expected from officers in his organization. His answer essentially echoes the Chief's critical combat capabilities: critical and strategic thinking, creative problem solving, moral discipline, and rapid innovation. Lt Gen Kwast acknowledged that his STEM background gave him a good measure of discipline and rigor, but noted that the habits of mind he listed had no correlation to STEM. In fact, the general stated that the rigor of STEM sometimes diminishes critical thinking capacities due to the "plug-and-play" nature of formulas and equations taught at the undergraduate level. Kwast stresses that familiarity with STEM does matter in regards to how technology is applied to the art of war, but in his estimation the three crucial attributes of a good strategist and national security thinker are understanding humanity, understanding the geopolitical environment, and building tools (e.g., technology,

methods, etc.) to bridge the two.[56] Developing these abilities requires appropriate habits of mind.

Habits of mind are cultivated and ripen through practice, but they germinate in the fertile soil of education. Given the complexity of the security problems faced by contemporary military forces, how we educate military officers to prepare them for these complex missions is of growing importance.[57] For a military officer, this education necessarily begins prior to commissioning. The following section explores the relative merits of STEM and non-STEM undergraduate education for developing the habits of mind required of future Air Force officers.

Planting the Seeds of Genius

The choice of an approach to study the world determines not only what one can say about the world, but also what one looks for and is able to see in the first place. Methods define the frames through which we construe the world.[58] Some methods have smaller frames than others. Mathematics, for instance, is a well-defined discipline, providing rigid pathways to right answers.[59] Those pathways are narrowly guided by concrete properties and laws. In the arts, the ends are held flexibly. That is to say, the particular aims to which a work is eventually directed need not be specified in advance with any degree of certainty. Artistic activity is opportunistic, exploiting new possibilities as they emerge.[60] Put in terms introduced in Chapter 2, mathematics and other STEM areas and concepts lend themselves to convergent thinking, the arts to divergent thinking. What does this mean for education?

[56] Kwast, in discussion with author, 21 April 2016.
[57] Silverstone, "Developing Strategic-Minded Junior Officers," 6.
[58] Eliot Eisner, *The Arts and the Creation of Mind* (New Haven, CT: Yale University Press, 2002), 215.
[59] Jack Lochhead and Judith Collison, "Critical Thinking Et Tu," in Fasko, *Critical Thinking and Reasoning*, 93.
[60] Eisner, *The Arts and the Creation of Mind*, 206.

Jean Piaget's theory of cognitive development still guides educational practice today. According to Piaget, although the key functional properties of cognition, specifically assimilation and accommodation, remained the same throughout development, the underlying structures of the thinking of children and adults differ in basic ways. Children's thinking is concrete in nature; children reason from the specific to the general and are constrained by perceptual properties. Adults (some at least) can reason formally, are not constrained by perception, and can reason from the general to the specific.[61] In other words, adults are better thinkers and ergo better problem solvers. A further implication is that these tendencies can be developed.

Recall from Chapter 2 the discussion of brain development in adolescence and early adulthood. The flexible and adaptable brain of an adolescent has an enormous potential for change. During this crucial period, the brain experiences an explosion of neuron production then almost immediately starts culling those neurons that are not exercised.[62] Some researchers believe that consistently reinforcing neural pathways with convergent thinking activities may be limiting pathways that support creative and divergent thinking. Conversely, increased divergent thinking changes the structure of the brain to further facilitate more divergent thinking and thereby better problem solving.[63] In light of this, the choice of a field of undergraduate study in young adulthood becomes more important.

Rhett Allain, a physics professor whose research focuses on physics education, laments that undergraduate science classes rely on

[61] Henry Markovits, "The Development of Thinking: Commentary," in Fasko, *Critical Thinking and Reasoning*, 166.
[62] Richard Restak, *The Secret Life of the Brain*, (New York, NY: The Dana Press and Joseph Henry Press, 2001), 72-73.
[63] David A. Sousa and Tom Pilecki, *From STEM to STEAM: Using Brain-Compatible Strategies to Integrate the Arts* (Thousand Oaks, CA: Corwin, 2013), 44-45.

detailed instructions and procedures in a reproductive (i.e., convergent) mode rather than an original productive one. As he puts it, "Science is creative, science classes are not."[64] In most college courses, instructors teach science primarily through lectures and textbooks that are dominated by facts and algorithmic processing rather than by concepts, principles, and evidence-based ways of thinking. This occurs despite ample evidence that many students gain little new knowledge from traditional lectures. Moreover, it is well documented that these methods engender passive learning rather than active engagement, boredom instead of intellectual excitement, and linear thinking rather than cognitive flexibility.[65] Allain notes that this stems partly from the fact that chemistry and physics are complicated for students, but probably more so because of instructors' habits – creativity in science is difficult to grade, whereas following instructions is easy to grade.[66] The fact that many science professors do not seek better ways to evaluate students supports the assertion that consistent reinforcement of convergent pathways negatively effects creative abilities.

This is not to say that scientific research and education should be discarded. Rather, it points to the importance of recognizing that science does not have a monopoly on the way human beings inquire of the world around them. The progress of the social sciences changed beliefs about research. In traditional research practice, the aim of research is to discover true and objective knowledge by simply unearthing facts or collecting data. This mechanistic view holds that research will show us what works and that once we know, it will also tell us what to do and how. This grossly oversimplifies things because of the inevitable gap

[64] Rhett Allain, "Science Education is Woefully Uncreative – That Has to Change," *Wired* (blog), 30 March 2016, http://www.wired.com/2016/03/science-education-woefully-uncreative-change/.
[65] Robert L. DeHaan. "Teaching Creativity and Inventive Problem Solving in Science," *CBE—Life Sciences Education* 8 (Fall 2009), 175.
[66] Rhett Allain, "Science Education is Woefully Uncreative."

between theoretical knowledge and practical action. Theories describe regularities, but particulars will deviate. Joseph Schwab reminded us that the theory of cows never applies perfectly to "Old Betsy."[67] Ignoring this gap implies that truth is independent of the perspective, frame of reference, values, or criteria researchers use to define truth. In reality, what counts as knowledge depends on perspective, time, interest, method, and form of representation. Put another way, knowledge and truth are socially constructed.

Business leader Paul Chellgren pushes back against the current focus on STEM skills for the workplace. Writing in response to cuts in arts programs and funding in schools, Chellgren notes that "[t]oday's students need arts education now more than ever. Yes, they need the basics. But today there are two sets of basics. The first – reading, writing, and math – is simply the prerequisite for a second, more complex, equally vital collection of higher-level skills required to function in today's world." The higher-level basics that Chellgren references include the ability to allocate resources; to work successfully with others; to find, analyze, and communicate information; to operate increasingly complex systems of seemingly unrelated parts; and finally to use technology. He argues that the arts – and other types of liberal education – provide an unparalleled opportunity to teach these higher-level basics that are increasingly critical for today's and tomorrow's workplace.[68]

The arts perform important cognitive functions. Training and practice in the creative arts provide a way of knowing. The arts help us learn to notice the world around us. Taking in the entirety of our environment through our perceptive senses, we can simultaneously notice the wholeness of the forest and the particularities of the trees.

[67] Quoted in Eisner, *The Arts and the Creation of Mind*, 212.
[68] Paul Chellgren, "What Good is Arts Education? Educating for the Workplace through the Arts," *Business Week*, 28 October 1996, 12.

The arts also give us permission to engage our imagination as a means for exploring new possibilities. Poetry frees us from the fetters of the literal. Fiction enables our stepping into the shoes of another. Impressionism develops a disposition to tolerate ambiguity, to explore what is uncertain, to exercise judgment free from prescriptive rules and procedures.[69] Creative, innovative, and critical thinking can only occur through experiences in interpersonal, work, and political lives characterized by breadth, depth, diversity, and different degrees of intensity. What is distinctive about liberal education is the search for meaning in these complex, contradictory, and ambiguous realities, and the process by which people develop critically reflective capacities.[70]

One tangible outcome of liberal education is the development of students' ability to understand art and technology as cultural artifacts. This allows one to examine forms and ask how the cultural values and beliefs influenced their making. This in turn develops a deeper understanding of cultures different from one's own. This is not limited to historical material. Contemporary forms and their design, whether motorcycles or laptop computers, are influenced by cultural values and the way business is conducted in a given society.[71] In other words, the arts, social science, and the humanities, go a long way to helping a student put norms and behaviors in a cultural context. This is a critical capability for military planners and leaders. The next section explores ways that multidisciplinary, liberal education cultivates the habits of mind needed by strategic thinkers.

Cultivating Strategic Thinkers

[69] Eisner, *The Arts and Creation of Mind, 10.*
[70] Stephen D. Brookfield, "Critical Thinking in Adulthood" in Fasko, *Critical Thinking and Reasoning,* 146-147.
[71] Eisner, *The Arts and Creation of Mind*, 89.

Recognizing that military education is deeply embedded in the broader framework of strategic action, we can identify the best way to develop the skills officers must possess and the things they need to know to link ways and ends in pursuit of national goals.[72] The CSAF identified those critical capabilities as creativity, innovation, and critical thinking. These attributes must be cultivated in the education of military officers prior to commissioning. An undergraduate education cannot provide all the answers to the problems officers will face during their careers. However, an effective education engenders critical habits of mind and provides guidance on the kinds of enduring, important questions officers should use to focus their own professional development. This thinking informs the integrated approach the British employ at the Royal Military Academy Sandhurst.

The 48-week commissioning course at Sandhurst uses a highly integrated approach teaching academic subjects alongside military training. Academic subjects are taught across three departments. They include the Department of Defence and International Affairs, the Department of War Studies, and the Department of Communications and Behavioral Science. The War Studies department focuses, as one would expect, on theories of war, maneuver warfare, expeditionary operations, insurgency and counterinsurgency, and officership. Communications and Behavioral Science courses are designed to deliver insight into what motivates people, group dynamics, and decision-making. Key themes include motivating, communicating and influencing, problem-solving, creative thinking, and negotiation skills.[73] This multidisciplinary approach acknowledges that junior officers must be brought up thinking holistically and strategically from the start. Recall from the previous

[72] Silverstone, "Developing Strategic-Minded Junior Officers," 6.
[73] An Jacobs, "Teaching IR at Sandhurst: Blended Learning through an Integrated Approach," *Infinity Journal Special Edition "International Relations in Professional Military Education*," Winter 2016, 51.

chapter that describing something as strategic emphasizes purposeful behavior, specifically, action that is logically linked to larger goals.[74] In doctrinal parlance, strategy is the linking of ways and means to desired ends.

To define any strategy, the relationship among the three nodes (ways, means, and ends) must rest upon sound and generalizable claims about human behavior. War, after all, is fundamentally a human endeavor, a "collision of two living forces."[75] Inherently complex and amorphous, the interaction of human forces, possibilities, probabilities, and luck prevent the reduction of war to mathematical calculation.[76] The very idea of strategy hinges on predictive claims of cause and effect. These claims answer the question, "What types of actions or conditions are likely to produce what kinds of outcomes?" These predictions must be rooted in the ability to draw from (and critically evaluate) generalizations, or theories, about human behavior.[77] The challenge for a military leader is to understand human, cultural, and political continuities of armed conflict, to identify complex variables at work that shape behavior, and with this insight into cause and effect, to develop the means that will produce the desired end state.[78]

Strategy is by nature multidisciplinary. Strategic thinking strives to make a creative and holistic synthesis of key factors affecting an organization and its environment in order to gain sustainable competitive advantage and long-term success.[79] These key factors encompass

---

[74] Scott A. Silverstone and Renee Ramsey, "Who Are We Teaching – Future Second Lieutenants or Strategic Leaders?: Education for Strategic Thinking and Action," *Infinity Journal Special Edition "International Relations in Professional Military Education*, Winter 2016, 12.
[75] Carl von Clausewitz, Michael Howard, and Peter Paret, *On War* (Princeton, N.J.: Princeton University Press, 1984), 77.
[76] Clausewitz, *On* War, 86.
[77] Silverstone, "Developing Strategic-Minded Junior Officers," 7.
[78] Scott A. Silverstone and Renee Ramsey, "Who Are We Teaching," 12.
[79] Charles D. Allen and Stephen J. Gerras, "Developing Creative and Critical Thinkers," *Military Review* 89, no. 6 (Fort Leavenworth, KS: US Army Combined Arms Center, Nov-Dec 2009), 78.

political, historical, economic, and other subjects affecting the utility of force and the pursuit of national objectives.[80] Understanding an adversary (or target population in the case of humanitarian intervention or counterinsurgency) is best facilitated through anthropological concepts: formal and informal economy; sociological, political, and religious systems; sociolinguistics; semiotics; and the society's concept of violence.[81] Of course, these factors simply form a foundation of understanding on which to build a strategy or strategic plan.

The real work of strategy-making involves generating alternatives, imagining their effect, and critically assessing the assumptions behind those predictions. Robert and Michele Root-Bernstein identified several tools that allow this kind of creative, innovative, and critical thinking. Their list includes, but is not necessarily limited to, observing, imaging, abstracting, recognizing patterns, analogizing, empathizing, dimensional thinking, modeling, playing, transforming, and synthesizing.[82] As demonstrated in earlier chapters, these cognitive activities are at the root of the Chief's three critical combat capabilities – creativity, innovation, and critical thinking. They also cross the domains of science and art.

The arts teach their practitioners to think within the constraints and affordances of a particular material or medium. Each material has its own distinctive qualities. Individuals need to work within the possibilities of the medium. For example, there is a difference between sculpting with clay or with marble. The former is additive, the latter subtractive. These differences have an extraordinary impact on what the artist needs to think about in using them. Each also imposes distinctive technical requirements with respect to the tools and procedures to use.[83]

---

[80] David Last, Ali Dizboni, and H. Christian Breede, "Does Canada Educate Strategic Subalterns?" in *Infinity Journal Special Edition*, Winter 2016, 41.
[81] Susan Craig, "Reflections of a Red Team Leader," *Military Review* 87, no. 2 (Fort Leavenworth, KS: US Army Combined Arms Center, March-April 2007), 58-59.
[82] Robert and Michele Root-Bernstein, *Sparks of Genius: The 13 Thinking Tools of the World's Most Creative People*, (New York, NY: Houghton Mifflin Company, 1999), 25.
[83] Eliot Eisner, *Arts and Creation of Mind, 236-237.*

These same nuances of constraint and affordance play out in devising strategy. What is the nature of the operation? Are the objectives concrete or malleable? What level and what type of force should we apply? Answers to these questions draw from knowledge and experience across domains. Habits to think critically and creatively are acquired only after considerable practice with thinking critically and creatively in a variety of contexts.[84] A liberal education provides such variety as it is by definition multidisciplinary – to include STEM subjects.

Fostering creative, innovative, and critical thinking skills requires a synthesized approach to education. As neuroscientist Nancy C. Andreasen notes, "…the 'silos' of language arts and biology and mathematics are in fact connected in very interesting ways."[85] Science and mathematics must be a central part of a twenty-first-century liberal arts education. Scientists, mathematicians, engineers, and technologists have their own way of thinking about and talking about the nature of our world, man-made and natural. They have their own vocabulary, their own ways of talking about ideas and problems, their own standards of proof, and their own methodologies. All undergraduates should become acquainted with these ways of knowing as approaches that are complementary to the insights offered by other fields. Students should be challenged to see how different ways of looking at the world can help them connect what they are learning in the classroom and lab to the world they will experience beyond the campus in an environment increasingly shaped by science and technology.[86] Of course, synthesis cuts both ways.

[84] Stephen P. Norris, "The Meaning of Critical Thinking Test Performance: The Effects of Abilities and Dispositions on Scores" in Fasko, *Critical Thinking and Reasoning,* 317.
[85] Nancy C. Andreasen, *The Creating Brain: The Neuroscience of Genius*, (New York, NY: Dana Press, 2005), 180.
[86] Judith A. Ramaley, "New Truths and Old Verities," *New Directions for Higher Education* 119, (Fall 2002), 15-16.

The education of STEM majors must foster the desired qualities of a liberally educated person. In addition to learning the habits of mind and forms of expression and inquiry of science and mathematics, students majoring in a STEM field should be expected to demonstrate the qualities of a person prepared to live a life that is productive, creative, and responsible. There are many approaches to articulating the purpose of education at the undergraduate level. All involve bringing together concepts of intellectual engagement and cognitive development with the fostering of emotional maturity and social responsibility. A college graduate should be informed, open-minded, and empathetic.[87] Charles Steinmetz, the “Wizard of Schenectady” and pioneer of alternating-current electricity, encouraged his engineering students at Union College to “study Greek, Latin, history, philosophy, and other subjects offered in the Liberal Arts College. The classics open the world of art and literature to the student. A neglect of them is one of the most serious mistakes. Technical training alone is not enough to fit a man for an interesting or useful life.”[88]

Summary

This chapter assessed the relative efficacy of STEM versus liberal arts education for inculcating creative, innovative, critical thinking habits of mind in Air Force officers. We began with a survey of general officer biographies to see if there are any clear trends that indicated whether one or the other type of degree better prepared officers for success. There is not. The undergraduate education of our current general officer corps is roughly evenly split between STEM and non-STEM disciplines. At the graduate level this changes. Twice as many general officers have non-STEM advanced degrees than have STEM advanced degrees. Additionally, a large majority of the STEM graduates do not work in Air

[87] Ramaley, “New Truths and Old Verities,” 18.
[88] Charles Steinmetz quoted in Root-Bernstein, *Sparks of Genius*, 326.

Force STEM specialties. These two facts make it clear that what really matters to the Air Force is not academic credentials, but rather technical skills and habits of mind.

The chapter then described the importance of the undergraduate experience in planting the seeds for particular ways of thinking. Early adulthood is a crucial time in brain development. Neurons form and decompose in a "use-it-or-lose-it" fashion according to the type of thinking that is exercised. Undergraduate education in STEM fields fosters linear convergent thinking. However, the world does not work in a linear way. War, as a human endeavor, certainly does not. Creative, innovative, and critical thinking habits of mind require holistic divergent thinking. The arts and other aspects of multidisciplinary liberal education exercise this type of thinking. This is not to say that awareness of science and math is not necessary. Rather, it shows that strictly limiting officer accessions to any particular way of thinking is a mistake. The United States after World War II is characterized by unbound technological progress. However, it was a society brought up with a liberal arts education that reconstructed an economically destroyed nation after the Great Depression and two world wars.

The chapter concluded with looking more specifically at how a multidisciplinary, liberal education prepared junior officers for the challenges they will face in their careers. Sandhurst provides a model for this approach with its focus on political and social science education alongside military training. As discussed in Chapter 1, USAFA uses a similar approach that focuses more heavily on STEM in granting Bachelor of Science degrees regardless of the discipline. Ultimately, this chapter shows that cultivating strategic thinkers requires a creative, holistic synthesis of social science, humanities, and STEM. The most important thing gained from such a liberal education is an appreciation of one's own thinking: its origins, elements, and motivations.

CONCLUSIONS AND IMPLICATIONS

> *We cannot afford to tolerate an anti-intellectual culture among airmen. …Our future leaders will have to be both very smart and mentally disciplined to deal effectively with the uncertainties and demands airmen will face in the "new world disorder." Our future leaders must understand airpower—not just airplanes. They must be able to think critically, analyze thoroughly, and synthesize logically.*
>
> - Col Dennis Drew, Retired
> *Educating Air Force Officers*

The spread of advanced technology, global economic and energy pressures, and the evolutionary forces of social change make the twenty-first century a time of unusual volatility. This is not to say that the nature of warfare will change over the next two decades. War will remain a human endeavor, a clash of wills between thinking adversaries; but the character of warfare is becoming far less predictable and more complex. No technology or technique will eliminate the fog and friction of war. There is no engineering solution to these very human problems. In the future, military advantage will rely more on brainpower than firepower.

The Chief correctly calls creativity, innovation, and critical thinking critical combat capabilities for the complex and uncertain future. The three are interrelated habits of mind. Specifically, they are cognitive processes driven by divergent thinking. Creativity is the capacity to produce novel, useful work that meets contextual constraints of a given domain. Innovation is the development of novel concepts, technologies, or methods to solve problems or deliver a decisive advantage in a particular social context. Creativity involves generating new and useful ideas; innovation puts those ideas in practice. Critical thinking is the process of identifying and challenging assumptions, and exploring and imagining alternatives in order to improve one's judgment and make better decisions. In other words, critical thinking is a creative process informed by reflective judgment, resulting in innovation. Like all habits

of mind, the Chief's critical combat capabilities can be purposefully developed.

For the Air Force to cultivate Airmen who can effectively lead the institution into the future, it must start by planting the right seeds. Commissioning sources are not merely producing second lieutenants who are proficient in a tactical environment. Newly commissioned second lieutenants are the future senior strategic leaders of the Air Force. Therefore, pre-commissioning education has strategic significance. Early adulthood is a crucial time in brain development. Neurons form and decompose in a "use-it-or-lose-it" fashion according to the type of thinking that is exercised. Undergraduate education in STEM fields fosters linear, convergent thinking. War, as a human endeavor, does not function in a linear way. Complex problems require holistic divergent thinking. The arts and other aspects of multidisciplinary liberal education exercise this type of thinking. This is not to say that awareness of science and math is not necessary. Rather, it shows that strictly limiting officer accessions to any particular way of thinking is a mistake. Unfortunately, the current approach to recruiting human capital remains mired in old technocratic paradigms.

Officer-recruiting efforts unnecessarily over-emphasize STEM degrees. A significant level of STEM-cognizance makes sense for a force that wields so much advanced technology. However, the rationale for limiting AFROTC scholarships to STEM majors fails under scrutiny. Most officer positions in the Air Force do not require a depth of technical or scientific expertise before commissioning. A large majority of STEM-degreed accessions become operators. However, half of all operators have non-STEM undergraduate degrees. Robust training provides operators and others the skills they need to build technical competency. Only five of 26 AFSCs have hard, mandatory requirements for STEM degrees. Authorizations in these specialties account for barely 10 percent of the total non-medical officer corps. Moreover, these

specialties all enjoy healthy manning levels. Recruiters must still ensure they fill these positions with the best-qualified individuals available, but this does not require limiting the pool of accessions to STEM-degree holders.

To meet the global challenges of the twenty-first century, the Air Force looks to position itself as a "profession of choice" in the competition for the country's top talent. This requires finding the best people to become Airmen. With constrained annual budgets and declining personnel strength, recruiting efforts are increasingly more critical and require more effort to access the individuals we need. Diverse backgrounds, experiences, and competencies will drive the innovative strategic perspectives needed to produce the agility the Air Force needs. The diversity of America brings a unique opportunity for the Air Force to draw from a wide talent pool. The CSAF vision calls on the institution to expand the search pattern beyond traditional recruiting pools to ensure the capable, inclusive force the future strategic environment requires. To reap the truly best talent America has to offer, we must eliminate institutional barriers to creating and retaining a diverse team.

This means reorienting to the idea that a blend of varied perspectives, cognitive approaches, and critical thought is a combat capability every bit as vital as high-tech hardware. Integrating this idea into all aspects of our operations requires individuals with demonstrated potential for creativity, innovation, and critical thinking. Identifying and capitalizing on those traits will require a more nuanced approach. Hence, three implications regarding officer accessions arise if the Air Force is to gather the best and brightest talent the nation has to offer and bring recruiting efforts in line with the CSAF's vision for the future.

First, recruiting efforts should immediately stop the singular focus on STEM degrees and cast a wider net. Narrowing the pool of potential accessions to a particular type necessarily limits the potential for fresh perspectives and novel ideas about airpower and the profession of arms.

As demonstrated above, the breadth of a liberal arts education inculcates diversity of thought and desired habits of mind in newly commissioned lieutenants. The ideal officer corps should be comprised of a broad mix of diverse backgrounds, skills, and points of view. Considering men and women of letters and of science is critical to realizing this ideal.

Second, the institution should recognize STEM-cognizance as sufficient for most Air Force specialties and develop means to assess it. Awareness of STEM principles is advantageous in a technically oriented service like the Air Force. A technical core such as that required for a Bachelor of Science degree certainly conveys this advantage, but is not the necessary solution. Rather, as suggested in the RAND and National Research Council studies, a better measure might entail a minimum number of credit hours in STEM courses regardless of degree type or major. Adopting this recommendation would prevent losing potentially brilliant officers simply because they prefer the lessons of history to the formulas of mathematics.

Finally, commissioning sources should implement assessments for creative and critical thinking as part of the vetting process for officer accessions. Academic degrees are an incomplete measure of skill and propensity for future success. Critical thinking assessments have gained purchase in the business sector. Such tools are widely available and could be administered in conjunction with the Air Force Officer Qualifying Test.

Several areas for further research suggest themselves. One might include examining demographic data to assess any correlation between educational background and mission readiness and career success measured by retention rates, promotion rates (including below, in, or above the zone), and other measures of success, such as attendance and academic performance in in-residence PME programs. The survey of general officer biographies in this study captured snapshots of the beginnings and pinnacles of individual officers' careers – snapshots

separated by 20 to 30 years. A longitudinal study could better account for contextual changes that might alter the relative value the Air Force places on different educational backgrounds and skills during an individual's career. Examples include the changing security environment or the rise of remotely piloted aircraft and cyber capabilities.

Another area that warrants further research is comparative analysis with other components of the US Armed Forces and the military services of other nations. Such analysis might center on the different approaches each service academy takes to determining and implementing the right curriculum to develop their future officers. Another approach could address Army and Navy ROTC scholarship programs. Of course, any such study should account for doctrinal and other contextual differences between the services.

In any case, the fact remains that newly commissioned second lieutenants are the future senior strategic leaders of the armed forces, including the Air Force. Therefore, getting officer accessions right has strategic significance. As the farmer serves as steward to his land, the soil of pre-commissioning education demands ongoing examination to ensure we plant the best variety of seeds and harvest the ripest fruits of genius.

BIBLIOGRAPHY

Academic Papers

Fino, Steven A. "'All the Missiles Work': Technological Dislocations and Military Innovation; A Case Study in US Air Force Air-to-Air Armament, Post-World War II through Operation Rolling Thunder". Drew Paper No. 12. Maxwell AFB, AL: Air University Press, 2015.

Allen, Charles D. "Creative Thinking for Individuals and Teams: An Essay on Creative Thinking for Military Professionals." Carlisle Barracks, PA: US Army War College, 2009.

Articles

Allen, Charles D. and Stephen J. Gerras. "Developing Creative and Critical Thinkers." *Military Review* 89, no. 6 (November-December 2009): 78-83.

Chellgren, Paul. "What Good is Arts Education? Educating for the Workplace through the Arts." *Business Week*, 28 October 1996, 12.

Craig, Susan. "Reflections of a Red Team Leader." *Military Review* 87, no. 2 (March-April 2007): 57-60.

DeHaan, Robert L. "Teaching Creativity and Inventive Problem Solving in Science." *CBE—Life Sciences Education,* no. 8 (Fall 2009), 172–181.

Drew, Col (Ret) Dennis, "Educating Air Force Officers: Observations After 20 Years at Air University," *Airpower Journal* 11, no. 2 (Summer 1997), 37-44.

Fastabend, Brig Gen David E. and Col Robert H. Simpson, "The Imperative for a Culture of Innovation in the U.S. Army: Adapt or Die," *Army* 54, no.2 (February 2004): 14-22.

Jacobs, An. "Teaching IR at Sandhurst: Blended Learning through an Integrated Approach." *Infinity Journal Special Edition International Relations in Professional Military Education* (Winter 2016): 50-55.

Krisinger, Chris J. "Who We Are and What We Do: The Evolution of the Air Force's Core Competencies." *Air and Space Power Journal* (Fall 2003): 15-25.

Last, David, Ali Dizboni, and H. Christian Breed. "Does Canada Educate Strategic Subalterns?" in *Infinity Journal Special Edition International Relations in Professional Military Education* (Winter 2016): 40-41.

Ramaley, Judith A. "New Truths and Old Veritie." *New Directions for Higher Education* 119 (Fall 2002): 15-19.

Silverstone, Scott A. and Renee Ramsey. “Who Are We Teaching – Future Second Lieutenants or Strategic Leaders?: Education for Strategic Thinking and Action.” *Infinity Journal Special Edition “International Relations in Professional Military Education* (Winter 2016): 10-15.

Silverstone, Scott A. “Introduction: Developing Strategic-Minded Junior Officers.” *Infinity Journal Special Edition “International Relations in Professional Military Education* (Winter 2016): 6-8.

Williams, Col Thomas M. “Understanding Innovation.” *Military Review* 89, no. 4 (July-August 2009): 59-67.

Books

Abuhamedh, Sami and Mihaly Csikszentmihalyi. “The Artistic Personality: A Systems Perspective.” in *Creativity: From Potential to Realization.* ed. Robert J. Sternberg, Elena L. Grigorenko, and Jerome L. Singer, 1st ed. Washington, DC: American Psychological Association, 2001.

Andreasan, Nancy C. *The Creating Brain: The Neuroscience of Genius.* New York, NY: Dana Press, 2005.

Biddle, Tami Davis. *Rhetoric and Reality: The Evolution of British and American Ideas about Strategic Bombing, 1914-1945.* Princeton, NJ: Princeton University Press, 2002.

Brookfield, Stephen D. “Critical Thinking in Adulthood” in *Critical Thinking and Reasoning: Current Research, Theory, and Practice.* ed. Daniel Fasko, Jr. Cresskill, NJ: Hampton Press, Inc., 2003, 143-163.

Brookfield, Stephen D. *Developing Critical Thinkers: Challenging Adults to Explore Alternative Ways of Thinking and Acting.* San Francisco, CA: Jossey-Bass Publishers, 1987.

Clausewitz, Carl von. *On War.* ed. Michael Howard, and Peter Paret. Princeton, N.J.: Princeton University Press, 1984.

Clodfelter, Mark. *Beneficial Bombing: The Progressive Foundations of American Air Power, 1917-1945*. Lincoln, NE: University of Nebraska Press, 2010.

Clodfelter, Mark. *Limits of Air Power: The American Bombing of North Vietnam.* Lincoln, NE: University of Nebraska Press, 2006.

Costa, Arthur L. “Communities for Developing Minds,” *Critical Thinking and Reasoning: Current Research, Theory, and Practice*. ed. Daniel Fasko, Jr. Cresskill, NJ: Hampton Press, Inc., 2003, 47-65.

Eisner, Eliot. *The Arts and the Creation of Mind.* New Haven, CT: Yale University Press, 2002.

Ennis, Robert H. “Critical Thinking Assessment,” in *Critical Thinking and Reasoning: Current Research, Theory, and Practice*. ed. Daniel Fasko, Jr. Cresskill, NJ: Hampton Press, Inc., 2003, 293-313.

Fasko, Daniel, Jr. "Critical Thinking: Origins, Historical Development, Future Directions," in *Critical Thinking and Reasoning: Current Research, Theory, and Practice*. ed. Daniel Fasko, Jr. Cresskill, NJ: Hampton Press, Inc., 2003, 3-18.

Gray, Colin S. *Airpower for Strategic Effect*, Maxwell AFB, AL: Air University Press, 2012.

Halpern, Diane F. "The 'How' and 'Why' of Critical Thinking Assessment" in *Critical Thinking and Reasoning: Current Research, Theory, and Practice*. ed. Daniel Fasko, Jr. Cresskill, NJ: Hampton Press, Inc., 2003, 355-366.

Harford, Tim. *Adapt: Why Success Always Starts with Failure*. New York, NY: Picador, 2011.

Harrington, Lisa M., Lindsay Daugherty, S. Craig Moore, and Tara L. Terry. *Air Force-Wide Needs for Science, Technology, Engineering, and Mathematics (STEM) Degrees*, (Santa Monica, CA: RAND, 2014).

Hayes, John. "Cognitive Processes in Creative Arts" in *Creativity: Being Usefully Innovative in Solving Diverse Problems*, ed. Stuart Nagel. Huntington, NY: Nova Science Publishers, Inc., 2000, 35-60.

Henderson, Sheila J. "Inventors: The Ordinary Genius Next Door" in *Creativity: From Potential to Realization*, ed. Robert J. Sternberg, Elena L. Grigorenko, and Jerome L. Singer, 1st ed. Washington, DC: American Psychological Association, 2001. 103-126.

Hughes, Thomas Alexander. *Over Lord: General Pete Quesada and the Triumph of Tactical Air Power in World War II*. New York: The Free Press, 1995.

Hughes, Thomas P. *Rescuing Prometheus: Four Monumental Projects that Changed the Modern World*. New York, NY: Vintage Books, 1998.

Hurley, Alfred F. *Billy Mitchell: Crusader for Air Power*. Bloomington: Indiana University Press, 1975.

Jervis, Robert. *Perception and Misconception in International Politics*. Princeton, NJ: Princeton University Press, 1976.

Khong, Yuen Foong. *Analogies at War: Korea, Munich, Dien Bien Phu, and the Vietnam Decisions of 1965*. Princeton, NJ: Princeton University Press, 1992.

Kraft, Ulrich. "Unleashing Creativity" *Best of the Brain from Scientific American: Mind, Matter, and Tomorrow's Brain.* New York, NY: Dana Press, 2007.

Kuhn, Thomas S. *The Structure of Scientific Revolutions*, 4th ed. Chicago, IL: University of Chicago Press, 2012.

Lasswell, Harold. "Cultivation of Creativity," in *Creativity: Being Usefully Innovative in Solving Diverse Problems*, ed. Stuart Nagel. Huntington, NY: Nova Science Publishers, Inc., 2000, 99-103.

Law, John. "Technology and Heterogeneous Engineering: The Case of Portuguese Expansion" in *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, ed. Wiebe E. Bijker, Thomas P. Hughes, and Trevor Pinch. Cambridge, MA: The MIT Press, 2012, 105-127.

Levesque, Lynne C. *Breakthrough Creativity: Achieving Top Performance Using the Eight Creative Talents* (Palo Alto, CA: Davies-Black Publishing, 2001).

Lochhead, Jack and Judith Collison. "Critical Thinking Et Tu," in *Critical Thinking and Reasoning: Current Research, Theory, and Practice*. ed. Daniel Fasko, Jr. Cresskill, NJ: Hampton Press, Inc., 2003, 89-96.

Lubart, Todd and Jacques-Henri Guinard. "The Generality-Specificity of Creativity: A Multidisciplinary Approach." in *Creativity: From Potential to Realization*, Washington, DC: American Psychological Association, 2004.

Markovits, Henry. "The Development of Thinking: Commentary," in *Critical Thinking and Reasoning: Current Research, Theory, and Practice*. ed. Daniel Fasko, Jr. Cresskill, NJ: Hampton Press, Inc., 2003, 165-184.

Michel, Marshall L. *Clashes: Air Combat Over Vietnam, 1965-1972*. Annapolis, MD: Naval Institute Press, 1997.

Miller, Donald L. *Masters of the Air: America's Bomber Boys Who Fought the Air War Against Nazi Germany*. New York, NY: Simon and Schuster, 2006.

Miller, Roger G. *To Save a City: The Berlin Airlift 1948-1949*. College Station, TX: Texas A&M University Press, 2000.

Mitchell, William "Billy". *Winged Defense: The Development and Possibilities of Modern Air Power – Economic and Military*. 1925. Reprint, Tuscaloosa, AL: University of Alabama Press, 2009.

Murray, Williamson, "Operation Iraqi Freedom, 2003," in *A History of Air Warfare*, ed. John Andreas Olsen, Washington, DC: Potomac Books, 2010, 279-296.

National Research Council, *Examination of the U.S. Air Force's Science, Technology, Engineering, and Mathematics (STEM) Workforce Needs in the Future and Its Strategy to Meet Those Needs*," (Washington, DC: National Academies Press, 2010), vii.

Norris, Stephen P. "The Meaning of Critical Thinking Test Performance: The Effects of Abilities and Dispositions on Scores" in *Critical Thinking and Reasoning: Current Research, Theory, and Practice*. ed. Daniel Fasko, Jr. Cresskill, NJ: Hampton Press, Inc., 2003, 315-332.

Pape, Robert A. *Bombing to Win: Air Power and Coercion in War*. Ithaca, NY: Cornell University Press, 1996.

Pinch, Trevor and Wiebe E. Bijker. “The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other” in *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, ed. Wiebe E. Bijker, Thomas P. Hughes, and Trevor Pinch. Cambridge, MA: The MIT Press, 2012, 11-44.

Posen, Barry R. . *The Sources of Military Doctrine: France, Britain, and Germany Between the Wars*. Ithaca, NY: Cornell University Press, 1984.

Restak, Richard. *Mozart’s Brain and the Fighter Pilot: Unleashing Your Brain’s Potential*. New York, NY: Harmony Books, 2001.

Restak, Richard. *The Secret Life of the Brain*. New York, NY: The Dana Press and Joseph Henry Press, 2001.

Roland, Alex and Philip Shiman. *Strategic Computing: DARPA and the Quest for Machine Intelligence, 1983-1993*. Cambridge, MA: MIT Press, 2002.

Root-Bernstein, Robert and Michele Root-Bernstein, “Artistic Scientists and Scientific Artists: The Link Between Polymath and Creativity.” in *Creativity: From Potential to Realization*, ed. Robert J. Sternberg, Elena L. Grigorenko, and Jerome L. Singer, 1st ed. Washington, DC: American Psychological Association, 2001, 127-152.

Root-Bernstein, Robert and Michele Root-Bernstein. *Sparks of Genius: The 13 Thinking Tools of the World’s Most Creative People*. New York, NY: Houghton Mifflin Company, 1999.

Rosen, Stephen Peter . *Winning the Next War: Innovation and the Modern Military*. Ithaca, NY: Cornell University Press, 1991.

Ruggiero, Vincent Ryan. “Neglected Issues in the Field of Critical Thinking” in *Critical Thinking and Reasoning: Current Research, Theory, and Practice*. ed. Daniel Fasko, Jr. Cresskill, NJ: Hampton Press, Inc., 2003, 369-380.

Schein, Edgar H. *Organizational Culture and Leadership*. 4th ed. San Francisco: Jossey-Bass, 2010.

Schlosser, Eric. *Command and Control: Nuclear Weapons, the Damascus Accident, and the Illusion of Safety*. New York, NY: Penguin Press, 2013.

Shimko, Keith L. *The Iraq Wars and America’s Military Revolution*. Cambridge, UK: Cambridge University Press, 2010.

Singer, Jerome. “Concluding Comments: Crossover Creativity or Domain Specificity?” in *Creativity: From Potential to Realization*, ed. Robert J. Sternberg, Elena L. Grigorenko, and Jerome L. Singer, 1st ed. Washington, DC: American Psychological Association, 2001, 195-203.

Sternberg, Robert, Elena L. Grigorenko, and Jerome L. Singer, eds. *Creativity: From Potential to Realization*. Washington, DC: American Psychological Association, 2004.

Sousa, David A. and Tom Pilecki. *From STEM to STEAM: Using Brain-Compatible Strategies to Integrate the Arts*. Thousand Oaks, CA: Corwin, 2013.

Springer, Sally P. and Georg Deutsch. *Left Brain, Right Brain: Perspectives from Cognitive Neuroscience*. 5th ed. New York, NY: W.H. Freeman and Company, 1998.

Tunner, William H. *Over the Hump*. 1964; New imprint, Washington, DC: Air Force History and Museum Program, 1998.

Worden, Col Mike. *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945-1982*. Maxwell AFB, AL: Air University Press, 1998.

Government Documents

Air Force R.O.T.C. *National Recruiting Strategy: The 2015 Vector*. Maxwell AFB, AL: HQ AFROTC/DOR, June 2015.

Air University. *AU Catalog 2015-2016*. Maxwell AFB, AL: Air University, 2015.

Department of the Air Force. *Air Force Future Operating Concept: A View of the Air Force in 2035.* Washington, DC: Department of the Air Force, September 2015.

Department of the Air Force. *America's Air Force: A Call to the Future*. Washington, DC: Department of the Air Force, July 2014.

Department of the Air Force. *Global Vigilance, Global Reach, Global Power for America*" Washington, DC: Department of the Air Force, August 2013.

Department of the Air Force. *Human Capital Annex to the USAF Strategic Master Plan*. Washington, DC: Department of the Air Force, 21 May 2015.

Department of the Air Force. *The World's Greatest Air Force, Powered by Airmen, Fueled by Innovation: A Vision for the United States Air Force*. Washington, DC: Department of the Air Force, 11 January 2013.

Department of the Air Force. *USAF Strategic Master Plan*. Washington, DC: Department of the Air Force, 21 May 2015.

Headquarters Air Force Personnel Center. *Air Force Officer Classification Directory: The Official Guide to the Air Force Officer Classification Codes*. San Antonio, TX: Air Force Personnel Center, October 2015.

Jumper, John P. *Chief's Sight Picture*, 15 January 2003.

Personal Communications

Kwast, Lt Gen Steven L. (Commander and President Air University), in discussion with author, 21 April 2016.

Websites

Air Force R.O.T.C. "Scholarships: Schools & Majors." https://www.afrotc.com/scholarships/schools.

Allain, Rhett. "Science Education is Woefully Uncreative – That Has to Change." *Wired* (blog), 30 March 2016. http://www.wired.com/2016/03/science-education-woefully-uncreative-change/.

Armstrong, Patricia. "Bloom's Taxonomy" Vanderbilt University Center for Teaching, accessed 27 March 2016, https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/#2001.

Department of the Air Force. "About Us." http://www.af.mil/AboutUs/Biographies.aspx

Jung, Rex. "Creativity and the Everyday Brain." interview by Krista Tippet, *On Being*, 22 March 2012. Transcript. http://www.onbeing.org/program/creativity-and-everyday-brain/transcript/1882.

Mauer, Maj Dan, "The 'Inception' Theory of Military Innovation." *Modern War Institute* (blog), 29 March 2016. http://www.modernwarinstitue.org/inception-theory-military-innovation/

Online Etymological Dictionary. s.v. "Renaissance man," accessed 29 February 2016, http://www.etymonline.com/index.php?search=Renaissance+man